2018

Exploring how Reflective Exercises affect First-Year Engineering Epistemological and Intelligence Beliefs

Amber J. Kemppainen
Michigan Technological University, amber@mtu.edu

EXPLORING HOW REFLECTIVE EXERCISES AFFECT FIRST-YEAR ENGINEERING EPISTEMOLOGICAL AND INTELLIGENCE BELIEFS

By

Amber J. Kemppainen

A THESIS

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in Applied Cognitive Science and Human Factors

MICHIGAN TECHNOLOGICAL UNIVERSITY

2018

This thesis has been approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE in Applied Cognitive Science and Human Factors.

Department of Cognitive and Learning Sciences

Thesis Advisor:	*Dr. Emily Dare*
Committee Member:	*Dr. Susan Amato-Henderson*
Committee Member:	*Dr. Adam Feltz*
Committee Member:	*Dr. Jon Sticklen*
Department Chair:	*Dr. Susan Amato-Henderson*

Table of Contents

List of figures

List of tables

Acknowledgements

I want to thank a number of individuals and groups that made this possible. First, I would like to thank my Lord and Savior, Jesus Christ for "I can do all things through Christ who strengthens me." (Philippians 4:13). I would like to thank my wonderful husband and my daughters for their support and understanding why mommy suddenly became addicted to coffee. Thanks to my friends and co-workers in the Engineering Fundamentals Department for their support and encouragement and help with data collection and the ENG1101 students who participated in this research. I would like to thank my wonderful current advisor, Dr. Emily Dare and past advisor, Dr. Susan Amato-Henderson, and my committee members, Dr. Adam Feltz, and Dr. Jon Sticklen, for their advice and for pushing me to make this work the best it can be. I would like to thank the faculty and staff of the Applied Cognitive Science and Human Factors Program for their help and sharing their knowledge. Lastly, I would like to thank the King-Chávez-Parks Future Faculty Fellowship Program who provided funding for me to pursue this degree and Michigan Technological University for their support through the employee education program.

Abstract

This work explores the effects of the implementation of a KWL reflective learning exercise on first-year engineering students' self-efficacy, intelligence beliefs (mindset), and epistemological beliefs. A sample of 428 first-year engineering students were divided into three groups: a) control, b) exposure to KWL, and c) used KWL. Significant differences were found in self-efficacy between the groups with more efficacious students being less likely to utilize the KWL activity. Seventy-seven percent of the students who used the KWL activities reported positive learning outcomes by using the KWL activity to focus their class preparation or to reflect on their learning. No significant effects of KWL implementation were found on student mindset or epistemological beliefs. There were changes in mindset with respect to gender. While 47.8% of students started with a growth mindset, by the end of the semester male students shifted towards a fixed mindset and female students maintained their growth mindset.

1 Introduction

I have taught first-year engineering students at Michigan Technological University (Michigan Tech) for the past fourteen years. In that time, I have watched many promising students leave engineering for other fields or leave higher education completely. A 2013 report from the National Center of Education Statistics (NCES) shows that this is not just a problem at Michigan Tech, but a problem nationally; approximately 41% of bachelor degree seeking engineering students left engineering between the years of 2003 – 2009. Of these, 21% switched out of engineering, but 20% left college without completing any degree (Chen, 2013). There is a higher probability that those switching majors are high-performing and/or female students, and those who leave college completely are low-performing students, male students, and/or low-income students (Chen, 2013). Michigan Tech's retention numbers are slightly higher than the national average with engineering graduation rates between 64.3% - 66.8% for the past five years (2011- 2016). It is interesting to note that Michigan Tech's first to second year retention rates are between 82-86%, indicating that approximately half of the students who leave engineering do so in their first year (Elenich & Russell, 2017). This suggests that the first year is a key time to provide interventions to retain engineering students if half the students who leave engineering do so during this time period.

The National Center of Education Statistics (2013) outlines four main reasons for students leaving STEM for non-STEM majors: 1) enrolling in few STEM courses during the first-year, 2) lacking academic challenges in first-year mathematics courses, 3) performing lower in STEM courses as compared to non-STEM courses, and 4) needing to withdraw from or failing a STEM course (Chen, 2013). In addition, a 2008 study of undergraduate student engagement determined that engineering students who become less motivated in engineering tend to leave engineering more quickly than comparable students who are less interested in other majors (Ohland et al., 2008). Engineering also has the lowest rate of students switching into the major from other majors (i.e., 7% into engineering as compared to 30-65% into other majors) (Ohland et al., 2008). This means that if a student initially declares a non-engineering major, they are not likely to switch into engineering. Engineering also attracts a lower rate of women (20%) compared to other majors (Ohland et al., 2008); this enrollment at Michigan Tech is no exception. Based on the reasons described above, effective ways to increase retention in engineering may be to ensure that engineering students are enrolled in engineering courses, that they are challenged in these courses, and that they succeed in these courses.

Success in undergraduate engineering means satisfactorily meeting all requirements for the major, including major coursework and general education requirements. Through this, they must demonstrate the strong analytical and problem-solving skills required to meet the proscribed student outcomes such as ABET 1-7 (www.abet.org). In addition, there is a need for engineering students to possess practical ingenuity (Phase, 2005). This means having the skill set to plan, combine, and adapt to the changing face of technology and globalization. Engineering students are expected to communicate well, be creative and collaborative, and have the cultural awareness, leadership, and entrepreneurial abilities necessary to be leaders in the global community (Ogando, 2006). Students who anticipate joining the engineering workforce need to have the "ability to learn new things quickly and [possess] the ability to apply knowledge to new contexts" (Phase, 2005, pg. 57). In short, students need to be prepared to be life-long learners.

I have come to believe that major factors in student persistence and becoming a life-long learner are having a growth mindset and sophisticated epistemological beliefs; reasons for this are elaborated in Chapter 2. In this thesis, I review the literature regarding engineering students' intelligence and epistemological beliefs and how these might be related to self-efficacy (Chapter 2). I discuss why having a growth mindset is particularly relevant for first-year engineering students, especially young women. This literature review also includes a discussion of classroom activities that have been shown to promote either epistemological beliefs or a growth mindset in students. The study described here uses one of these activities - a reflective learning activity known as KWL - in the first-year engineering program at Michigan Tech to understand how an activity like this impacts students' self-efficacy, intelligence beliefs, and epistemological beliefs (Chapter 3).

Any changes in self-efficacy, intelligence beliefs (mindset), and epistemological beliefs were measured through pre-and post-surveys. Students in the experimental groups additionally reflected on the effectiveness of the KWL classroom activity on their learning at the end of the semester through an open-ended survey. Results and conclusions (Chapter 4 and 5) regarding the changes in the aforementioned measures and the effectiveness of the KWL activity are discussed.

2 Literature Review

2.1 Epistemological Beliefs

Epistemology is a branch of philosophy that focuses on the study of human knowledge: what it is, where it starts, and what the limitations are (Stroll & Martinich, 2016). Epistemology has been studied by philosophers since ancient Greece, increasing our understanding of how these beliefs affect personal intellectual development (Hofer, 2004). Current epistemology is focused on two areas: 1) describing what kinds of mental content counts as knowledge and 2) determining what kinds of beliefs can be rationally justified (Stroll & Martinich, 2016). In the late 1950s, epistemology gained the attention of educational psychologists such as William G. Perry Jr. In a longitudinal study from 1954 to 1963, Perry interviewed first-year Harvard students about their college experiences as related to learning and knowledge acquisition (Perry, 1999). From these data, Perry assembled a hierarchy of nine levels of knowledge acquisition as shown in Figure 2.1 below. These levels are divided into four main areas of development, all of which a student may not master. The first few levels (1-3) focus on students moving from absolute dualism (right vs. wrong) to accepting that knowledge is more complex than this simplistic viewpoint. The next few levels (4-6) focus on the continued development of relativism (e.g., looking at and integrating other approaches and viewpoints). Finally, the last three levels (7-9) focus on the student commitment to a relativistic viewpoint (Perry, 1999). These levels are discussed in more detail below.

The first two levels of epistemological beliefs of knowledge are labeled as Simple Dualism. In Simple Dualism students believe in right and wrong exclusively, trusting that their instructors know the answers; their faith in these authorities is not questioned (Perry, 1999). This is the simplest of epistemological beliefs of knowledge acquisition. Students who move to Perry Levels 3 and 4 (Complex Dualism) start to see that exceptions to right and wrong exist. At Level 3, students continue to believe these exceptions only exist because the authorities have not yet found the answer. However, at Level 4, students start to either realize that their instructors are fallible and that uncertainties do exist, or they start to find ways to bend their thinking in ways the authority approves. An example might be a student finding “more than one approach to a problem” (Perry, 1999, p. 111). Some students never progress past this point and may try to retreat from this level of thinking and entrench themselves in Simple Dualism (Perry, 1999).

Within Perry’s Levels 5 and 6 (Relativism), students begin to understand that all knowledge is contextual and that dualistic right vs. wrong situations apply to few situations. Their epistemological beliefs advance to the point where they realize that a commitment to this way of thinking is necessary to their development as a learner. The last three Perry levels (Commitment to Relativism) refer to a commitment made by students. In Level 7, students make conscious decisions in some major area of their lives that require a commitment. Level 8 reflects the experiences necessary to understand what that commitment might entail. Level 9 reflects the emotional and intellectual maturity necessary to identify with that commitment (i.e., a person not only understands what the commitment might entail, but they are capable to see the commitment through) (Perry, 1999). Within the sample of 120 Harvard students used in this study, approximately half

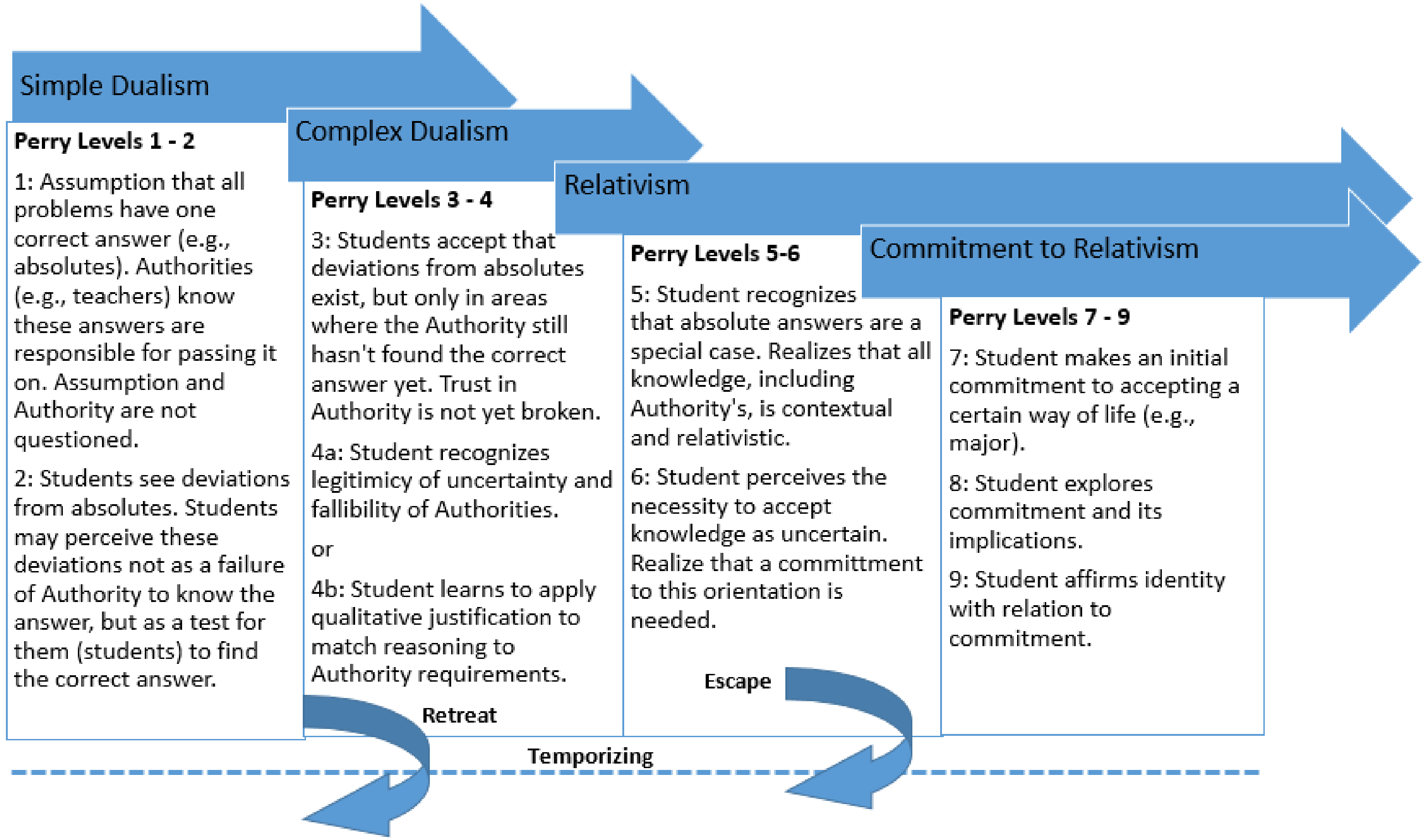


Figure 2.1 Perry's Model of Intellectual Development
Adapted from Perry Jr, W. G. (1999). Forms of Intellectual and Ethical Development in the College Years: A Scheme. Jossey-Bass Higher and Adult Education Series. © 1999 by Jossey-Bass Publishers, 350 Sansome St., San Francisco, CA 94104

achieved some level of commitment by the end of their junior year, with most achieving this their senior year. Only three students were rated in Level 7 or higher at the end of the first-year and 11 by the end of the sophomore year (Perry, 1999). This would indicate that students progress through these levels differently and, while a few may have developed sophisticated epistemological beliefs early in their undergraduate careers, approximately half of the students do not do so until their final year.

While Perry's model shows development of epistemological beliefs throughout nine levels (Figure 2.1), the model also has three modes of deflection that may interfere with students' development as learners: temporizing, escape, and retreat. As noted by Perry, students may choose these modes when they feel "unprepared, resentful, alienated, or overwhelmed" (Perry, 1999, pg. 65). Escape might take the form of denying or rejecting their epistemological growth (Perry, 1999). For example, a student might choose to obey the dictates of an assignment to get a good grade, but does not try to learn from the experience. A student who retreats becomes entrenched in the beliefs of a particular level when confronted with the complexities of the next. For example, a student may retreat to the beliefs of Complex Dualism when confronted with the intellectual efforts of Realism (Perry, 1999). Temporizing is when students deliberately delay or hesitate before moving onto the next level of Perry's model. These students might eventually advance to the next level, but may also chose to escape or retreat. Before making this final decision, however, students who are temporizing delay or hesitate.

2.1.1 Measuring Epistemological Beliefs

Several measures of epistemological beliefs were developed to assess student epistemological beliefs and their growth: the Epistemological Questionnaire (EQ) (Schommer, 1990), the Epistemological Beliefs Instrument (EBI) (Jacobson & Jehng, 1999), the Discipline-focused Epistemological Beliefs Questionnaire (DEBQ) (Hofer, 2000), and the Epistemological Beliefs Assessment for Physical Science (EBAPS) (Elby, Frederiksen, Schwarz, & White, 2003). While these surveys measure epistemological beliefs, most also investigate student course or learning expectations to determine how these beliefs and expectations interact. For example, the EBAPS looks at epistemological beliefs on the nature of knowing and learning and how knowledge evolves, but also examines student beliefs surrounding their ability to learn (Elby et al., 2003). Schommer's Epistemological Questionnaire not only investigates epistemological beliefs on knowledge structure, certainty, and source, it also includes questions related to control and speed of knowledge acquisition (Schommer, 1990).

Using the EQ, Schommer and Walker (1995) noted levels of epistemological beliefs across domains similar to Perry (1999). A survey of 114 undergraduate students reported a level of sophistication in epistemological beliefs that may differ by domain. In this case, students displayed stronger certainty beliefs in the mathematics domain than in social sciences (Schommer & Walker, 1995). This seems to indicate that, while students may tend toward a certain level of sophistication in their epistemological beliefs, these levels may vary across disciplines. Researchers also found that these lower sophistication beliefs (i.e., certainty beliefs or lower Perry levels) predicted lower course grades

(Paulsen & Wells, 1998; Schommer, 1990; Trautwein and Lüdtke, 2007). In addition, researchers observed that the more students possess underdeveloped epistemological beliefs, the more likely they are to provide overly simple interpretations and conclusions to problems (Schommer, 1990).

2.1.2 Epistemological Beliefs in Undergraduate Work

A review of the literature regarding epistemological beliefs and undergraduate engineering students suggests that there are differences between engineering and other majors (Hofer, 1994; Hofer, 2000; Jehng, Johnson, & Anderson, 1993; Schommer-Aikins, Duell, & Barker, 2003). Paulsen & Wells (1998) found that "students majoring in engineering were significantly more likely to have naïve beliefs in certain knowledge than students majoring in the humanities and fine arts and the social sciences" (p. 372). Several studies indicate that first-year engineering students tend to display Simple Dualism thinking (Perry Levels 1 or 2) (King & Magun-Jackson, 2009; Wise, Lee, Litzinger, Marra & Palmer, 2004) or begin to embrace Complex Dualism (Perry Levels 3 or 4) (Marra, Palmer & Litzinger, 2000). According to Jehng et al. (1993), undergraduate students, particularly in business and engineering believe that knowledge is certain and can only be obtained by trusted authorities through a linear problem-solving process (Jehng et al., 1993). Focusing only on a linear process may prevent students from looking at a problem in more than one way (Level 4 or 5), which limits the potential solutions to a problem and does not advance their epistemological beliefs. Researchers point out that students in arts, humanities, and social sciences are required to rely on their own interpretation and reasoning due to the nature of these fields. This helps students in these fields develop their epistemological orientations (e.g., moving from accepting knowledge as certain to uncertain) further than students in engineering (Felder & Brent, 2004a; Jehng et al., 1993; Palmer & Marra, 2004; Paulsen & Wells, 1998; Trautwein & Lüdtke, 2007).

The general trend is for epistemological beliefs to become more advanced as students progress through their undergraduate curriculum (King & Magun-Jackson, 2009; Perry, 1999; Schommer, 1990). However, engineering students do not seem to advance as quickly or as far through the Perry levels compared to students in other fields. Trautwein & Lüdtke (2007) found that, over the course of their longitudinal study, engineering students increased in their certainty beliefs (i.e., became less sophisticated in their epistemological beliefs), while all other majors studied increased in the sophistication of their epistemological beliefs (Trautwein & Lüdtke, 2007). Other researchers have shown that engineering students only increased one Perry level on average throughout their undergraduate education, with most of this increase occurring during their final year (Pavelich & Moore, 1996; Wise et al., 2004). Wise et al., (2004) attributed this to the fact that often the first two years of undergraduate education are used for learning the basic knowledge of the major without higher-level developmental activity.

To summarize, it appears that engineering students possess, on average, lower and less sophisticated epistemological beliefs than students in other fields do, but more importantly, do not advance in their beliefs very quickly or at all. With lower epistemological beliefs correlated with lower academic performance (i.e., grades), it is important to find ways to develop these beliefs in first-year engineering students so that they can succeed in their engineering major. Because of the emphasis of engineering education on basic knowledge (general sciences and mathematics), expanding epistemological beliefs of engineering students within their first two years of undergraduate education may be difficult to do.

Finding ways to increase the epistemological beliefs of first-year engineering students may help increase performance in their core coursework. Because progressing away from certainty beliefs may be more difficult for engineering students, instructors should make efforts to incorporate materials and educational methods that "reflect the tentative nature of human knowledge" (Trautwein & Lüdtke, 2007, p. 362). Creating situations in the classroom where students are forced to face ambiguities or uncertainties regarding knowledge might be one way to increase these skills. However, the development of epistemological beliefs is just one aspect that affects student persistence in engineering. Student beliefs about intelligence also affect how they perceive how learning occurs and their own potential to learn.

2.2 Intelligence Beliefs

Epistemological beliefs are often intertwined with beliefs about intelligence. There are two main theories of intelligence and learning outlined by Dweck (2016), which are outlined in Figure 2.2. These theories relate to one's belief about how intelligence is developed. The first of these theories is entity learning. A person who believes in entity learning would say that their intelligence is fixed; a person is only given a certain amount of intelligence and no matter what they do and this will not change over their lifetime.

Therefore, someone who subscribes to this theory believes that some people are gifted intellectually and others are not. Oftentimes, this is referred to as having a fixed mindset. These individuals believe some people are superior to others because of natural talent, and they should not have to try hard to be successful; hard work is not necessary for someone who is innately intelligent (Dweck 2016). To reinforce this belief, they gravitate toward situations that allow them to showcase their superiority and avoid challenging situations where they could fail. If failure should occur, often these individuals will react defensively or find excuses to explain why they were not successful instead of using these failures to improve their knowledge and skills. Someone with a fixed mindset may not work well with others and feel threatened when someone else is successful (Dweck, 2016). Because individuals with a fixed mindset focus only on activities where they are successful, they often plateau in their abilities due to their self-created limitations.

The second theory proposed by Dweck (2016) is incremental learning. A person who believes in incremental learning believes that they can always improve their intelligence by modifying their learning efforts, making intelligence changeable, malleable, and constantly evolving (Dweck, 2016); this is commonly referred to as a growth mindset. Individuals with a growth mindset believe that intelligence can be improved, and they seek opportunities to improve their skills. They see challenging opportunities and failures as learning experiences, which allows them to persist through failures; putting in hard work is a way that they can develop the skills they did not have initially. This effort is valued and will always help them improve. These individuals often

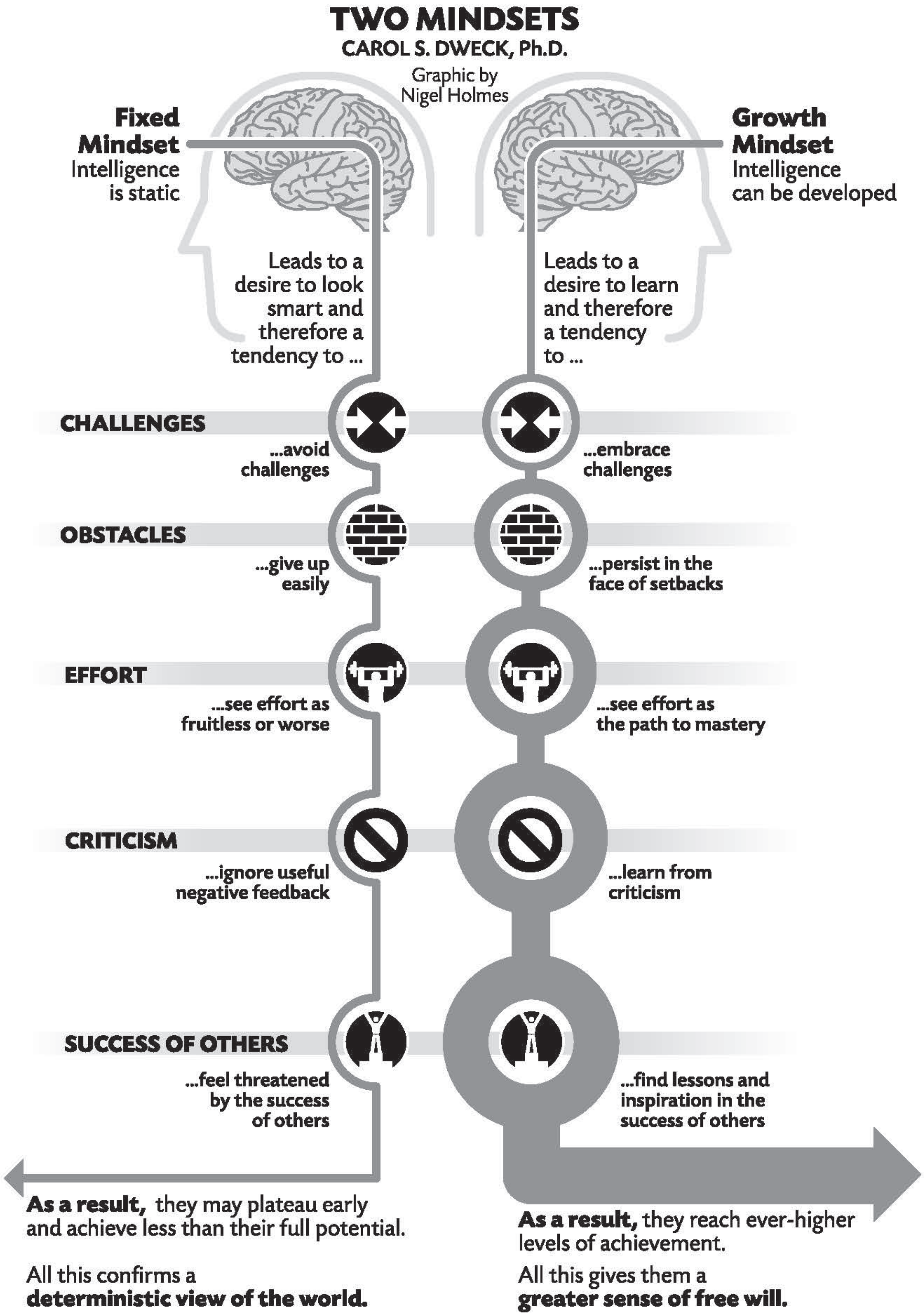


Figure 2.2 Two Mindsets, © 2016 by Nigel Holmes

work well in teams, valuing the individual contributions, comments, and viewpoints of each team member. As growth-mindset individuals continue to improve their intelligence, they do not plateau, as fixed mindset individuals do, but continue to achieve more and at higher levels. An incremental view of intelligence is positively correlated with the more sophisticated epistemological beliefs about the justification and development of knowledge (Chen & Pajares, 2010). In other words, having a growth mindset may help develop epistemological beliefs.

It should be noted that while there are two main theories, a person may not necessarily be exclusively one mindset or the other, but somewhere along a continuum (Dweck, 2016). In general, using the Implicit Theories of Intelligence Scale (Dweck, 1999), approximately 40% of United States students (middle school through university) possess a fixed-mindset, 40% possess a growth-mindset and 20% of students are somewhere in between (Dweck, 2008).

2.2.1 Intelligence Beliefs and Academic Performance

Several studies demonstrated the importance of growth mindset on academic achievement and learning strategies employed by students and the effects of fixed mindset on the same. For example, eighth-grade students who endorsed a fixed mindset showed significantly lower levels of intrinsic motivation than those students who endorsed a growth mindset (Haimovitz et al., 2011). Another example showed that 6th grade students with a growth mindset earned higher grades and took more challenging coursework than their fixed mindset peers (Romero et al., 2014). In a study of undergraduate students enrolled in a statistics class, students with a growth mindset showed higher gains from midterm to final exam (Aditomo, 2015). Students with a growth-mindset are more likely to put in the effort necessary to learn course material (Blackwell, Trzesniewski, & Dweck, 2007), earn higher grades and pursue more challenging coursework (Romero et al., 2014). A 2014 survey of 377 undergraduate mechanical, aerospace, and electrical engineering students (17.2% female, 84% upper-level courses) indicated that those students who held stronger incremental beliefs (growth mindset) were more likely "to engage in knowledge-building behaviors or collaborative learning strategies" (Stump et al., 2014, p. 1). One meta-analysis indicated that incremental theories of intelligence significantly predicted several self-regulatory learning processes such as goal setting, operating, and monitoring (Burnette, O'boyle, VanEpps, Pollack, & Finkel, 2013).

While these studies show a positive relationship between a growth mindset and academic achievement, a clear, definitive relationship is yet to be determined as demonstrated from the following two studies. A 2014 survey of 377 undergraduate mechanical, aerospace, and electrical engineering students (17.2% female, 84% upper-level courses) revealed a) that students' incremental beliefs were significantly stronger than entity beliefs (i.e., growth mindset > fixed mindset) and b) no relationship between mindset and academic performance existed (Stump et al., 2014). Bahnik and Vranka (2017) also did not find a significant relationship between mindset and performance on a scholastic aptitude test. While the majority of the studies demonstrate (e.g., Aditomo, 2015; Blackwell, Trzesniewski, & Dweck, 2007; Burnette et al., 2013; Romero et al., 2014) positive relationships between mindset and academic success, these two studies failed to confirm those results. As a result, this relationship should be investigated further as the true effect of mindset on academic performance is unclear.

2.2.2 Gender and Intelligence Beliefs

In addition to the effects from mindset on academic performance discussed in the previous section, there are additional challenges that may affect performance that need to be considered. Intelligence and epistemological beliefs can be directly affected by beliefs and stereotypes particularly regarding gender and ethnicity. Beliefs regarding gender and mathematical ability have been shown to negatively affect how women pursue and persist in STEM fields (Correll, 2001; Dweck, 2008; Dweck 2016). Female students in particular are less likely to have a growth mindset about mathematics and science topics as compared with male students (Chen & Pajares, 2010). Research has shown that fixed beliefs in science ability "have a negative indirect effect on science achievement, largely mediated through epistemological beliefs about the source and certainty of knowledge" (Chen & Pajares, 2010, p. 28). This suggests that students who have a fixed mindset in science are more likely to have lower sophistication with regard to certainty beliefs and have lower performance in science. In addition, there are numerous studies showing how stereotype threat negatively affects performance (Nguyen & Ryan, 2008). Several researchers suggest that educators can work to counter stereotypes and build confidence in female and minority students by encouraging the development of a growth mindset (Achenbach et al., 2015; Boaler, 2013; Gibbon & Jandrell, 2012; Rogers et al., 2016).

Looking at studies on engineering students reveals interesting trends regarding mindset and gender. While middle and high school female students are more likely than male students to hold fixed mindset beliefs about mathematics and science ability (Chen & Pajares, 2010; Correll, 2001; King & Magnun-Jackson, 2009), there is research to suggest that this may not be true of female engineering students at the undergraduate level. A 2009 survey of undergraduate and graduate engineering students, King and Magun-Jackson found that intelligence beliefs differed with regard to gender, previous academic achievement (i.e., high school GPA), and ethnicity. Their findings indicated that female students and students with high GPAs tend to have stronger beliefs in fixed ability (King & Magun-Jackson, 2009). However, a study of 1093 students (20.1% female, 79.9% male) in a high-school engineering course between 2011 and 2015 indicated that there were no significant differences between gender and mindset (Rogers et al., 2016). However, if there is a gender effect on mindset, this may prove problematic for the retention of female engineering students. If women are more prone to a fixed-mindset on mathematics and science ability, any negative feedback received in those two areas may push women away from engineering, a career path that uses both heavily.

2.2.3 Intelligence Beliefs and Challenges

As mentioned previously, students who possess a growth or fixed mindset respond differently to challenges. In particular, “mindsets about intelligence and ability become more important in the face of challenge in actual academic setting” (Aditomo, 2015, p. 215). Bandura (2001) states that “unless people believe they can produce desired results and forestall detrimental ones by their actions, they have little incentive to act or to persevere in the face of difficulties” (p. 10). Therefore, it would seem that students with a fixed mindset (i.e., belief their intelligence cannot change) who score poorly on a test, might feel that they cannot do better even if they tried harder. Their belief system would indicate that they have no control over their intelligence and failure would mean no chance for success in this area. A fixed mindset limits the potential achievement of the students and limits the areas where they feel successful. However, a growth mindset may help an individual overcome a challenging situation. This is exemplified in the 2016 study by Claro, Paunesku, and Dweck on a nationwide sample of 168,553 of Chilean high school students with respect to poverty, mindset, and academic achievement. Student mindset reliably predicted 11.8% of the variance in test scores on language and mathematics with students who possessed a fixed mindset and from a low-income household having a compounded negative effect on their test scores. Students from a low-income background and who possessed a growth mindset performed as well as students with a fixed mindset in the 80% income level (Claro, Paunesku, & Dweck, 2016). In this case, having a growth mindset buffered against the challenge of coming from a low-income background.

2.2.4 Effects of Growth Mindset Instruction

Studies have shown that explicit instruction of mindset improved growth mindset beliefs, increased perception of value of academics, countered effects of stereotypes, and improved performance in students (Dweck, 2010a; Dweck, 2010b). This instruction may take the form of a) an explanation of growth mindset (Dweck, 2010a), b) a workshop (Dweck, 2010b), c) class sessions on mindset (Powers, 2015), or c) mentoring emphasizing growth mindset (Good, Aronson, & Inzlicht, 2003). For instance, seventh-grade students who participated in a growth mindset workshop increased their mathematics grades significantly, but those that did not have this experience continued to do poorly in future mathematics coursework (Dweck, 2010b). Community college students who received growth mindset instruction in their English classes increased in their growth mindset and transferred this to other classes (e.g., math) (Powers, 2015). Students in a mentoring program with mentors who emphasized and explicitly discussed growth mindset significantly increased their math and reading scores over those students who did not (Good et al., 2003).

Instruction on growth mindset has been shown to decrease or close the achievement gap between stereotyped and non-stereotyped groups, allowing students in traditionally stereotyped groups (e.g., Black, women) to perform as well as their non-stereotyped peers (e.g., White, male) (Dweck, 2010a; Good et al., 2003; Hill, Corbett, & St Rose, 2010). In addition, the gain shown by instruction or interventions that promote growth mindset appeared to be more significant in African-American students over other ethnic groups (Aronson, Fried, & Good, 2002; Dweck, 2008). This seems to suggest that interventions designed to promote growth mindset might help alleviate issues related to stereotype threat for women and minorities.

To summarize, having a growth mindset allows students to see that a) working hard is the key to developing skills, b) challenging problems are opportunities to learn, and c) continuing efforts can continue to advance their skills (Dweck, 2016). Students who have a growth mindset have been shown to perform better academically (Aditomo, 2015; Blackwell et al., 2007). Growth mindset has been shown to help mitigate the negative effects of challenging situations on performance (Claro et al., 2016) and close the performance gap created by stereotype threat (Dweck, 2010a; Good et al., 2003; Hill et al., 2010).

2.3 Self-Efficacy

As mentioned previously, an individual's judgements of their capabilities to perform is known as self-efficacy (Bandura, 1986). Self-efficacy affects an individual's thoughts (e.g., self-enhancing or self-obstructing), self-regulation ability, and choices with regard to challenges (Bandura, 2001). Self-efficacy is positively related to mastery goals (Hsieh, Sullivan, & Guerra, 2007), academic achievement (Adeyemo, 2007; Lent, Brown, & Larkin, 1986; Marra, Rodgers, Shen, & Bogue, 2009), and academic resilience (Cassidy, 2015). Students with high self-efficacy are more likely to have high academic performance and set mastery goals for themselves (goals for learning). Further, self-efficacy and intrinsic motivation are correlated with sophisticated epistemological beliefs (Hofer, 1994).

Self-efficacy may be linked to mindset. For example, theories of intelligence become more crystallized as children age, but children as young as 11 or 12 years old may begin to view ability and intelligence as a capacity or fixed trait (Dweck, 2002). These beliefs about ability and intelligence become linked (e.g., an ability in an area indicates intelligence in that area), affecting motivation and performance. Individuals may see these domains as different intellectual areas such as reading, science, or mathematics or different abilities such as athletic, artistic, or musical (Dweck, 2002). Low self-efficacy beliefs (judgements of their capabilities to perform) in a specific domain or a fixed mindset in that domain, increases an individual's desire to avoid that domain. This suggests that if a student perceives that they are not good at a particular subject (e.g. low self-efficacy), or they do not have abilities in a certain area (e.g., fixed mindset), they may avoid future courses or careers that use that skill or ability heavily. For example, Pajares and Miller (1994) state that mathematics self-efficacy is a significant predictor of mathematics performance. This indicates that lower self-efficacy in mathematics may negatively affect mathematics performance, one of the cornerstones of STEM career pathways.

Traditionally, students who excel at science and mathematics are most likely to pursue and be retained in STEM fields such as engineering (Summers & Hrabowski III, 2006). However, low self-efficacy in these topics has been shown to impact retention in engineering, especially for women and minority students (e.g., Betz & Hackett, 1981; Hutchison, Follman, Sumpter & Bodner, 2006; Hill et al., 2010; Lent et al., 2008; Marra et al., 2009; Pajares & Miller, 1994; Rogers, Primeau, Hennessey, & Baygents, 2016; Summers & Hrabowski III, 2006). As mentioned previously, in addition to lower self-efficacy in these areas, female students are less likely to have a growth mindset about these topics as compared with male students (Chen & Pajares, 2010). This may suggest a connection between self-efficacy and growth mindset as women typically have lower self-efficacy in STEM disciplines.

Correll (2001) noted that female students were more likely to rate themselves lower than male students on self-assessments of mathematics ability; this is particularly true if female students had received high scores in another topic such as verbal ability. In this case, success in one area lowered perceptions of success in another (Correll, 2001). In another case, Parsons, Adler, and Meece (1984) noticed that success or failure on a mathematics test was attributed to perceived mathematics ability by female students more than males. Female students are more likely than male students to validate their own competency on a task using performance feedback (Parsons et al., 1984). In other words, a poor grade on a test or negative feedback from an instructor will be considered more by female students as an indicator of their own ability or lack thereof. Despite completing the same number of same mathematics and science high school credits with higher grades, female students continue to perceive themselves as being less successful at these topics (Hill et al., 2010).

A survey of first-year engineering students at Purdue University revealed that their course experiences helped shape their engineering self-efficacy (Hutchinson et al., 2006). Students expressed that the following positively affected their self-efficacy toward their engineering course success: mastery of course material, personal motivation, team support, programming abilities, problem solving abilities, and assignment completion (Hutchinson et al., 2006). Students who were not able to understand a concept, were not in a supportive team, had lower programming abilities, were not able to complete assignments or solve problems may perceive a negative impact on their self-efficacy (Hutchinson et al., 2006). This aligns to Bandura's efficacy expectations with mastery or performance experiences being a principle source of self-efficacy with "successes rais[ing] mastery expectations; repeated failures lower[ing] them" (Bandura, 1977, p. 195). This also corresponds with Dweck's theories on the development of fixed intelligence beliefs with failure and success being attributed to a lack of ability and ability respectively (Dweck, 2016).

To summarize, self-efficacy has been shown to be a significant predictor of academic performance (Adeyemo, 2007; Lent, Brown, & Larkin, 1986; Marra et al., 2009), student motivation (Dweck, 2002; Hofer, 1994), and retention in engineering for women and minorities (Betz & Hackett, 1981; Hutchison et al., 2006; Hill et al., 2010; Lent et al., 2008; Marra et al., 2009; Pajares & Miller, 1994; Rogers et al., 2016; Summers & Hrabowski III, 2006). Further, there appears to be a relationship between self-efficacy and intelligence beliefs (Dweck, 2002). The exact nature of this relationship, especially with respect to engineering students, needs to be investigated further.

2.4 Curriculum Development for Growth Mindset

There are many ways instructors can help foster a growth mindset in their students, beginning with how instructors communicate with their students. Research has shown that praising effort rather than intelligence encourages a growth mindset, while praising intelligence rather than effort tends to foster a fixed mindset (Dweck, 2007; Dweck 2016; Hogan & Larkin-Wong, 2013). Felder and Brent (2005) suggest that challenging epistemological beliefs of students (e.g., problems have one answer, instructor is infallible, knowledge is certain) is essential to improve those beliefs. For instance, Felder and Brent (2004b) suggested that a gradual increase in the amount of ambiguous and/or poorly-structured problems throughout undergraduate curriculum might be a way to increase the level of knowledge acquisition. The authors emphasize these should be few in the beginning of the curriculum with a large amount of guidance on how to solve these types of problem and move toward a large number of such problems with little to no guidance by the end of the senior year (i.e., scaffolding) (Felder & Brent, 2004b).

Several researchers claim that students grow intellectually through facing challenging problems (Dweck, 2016; Felder & Brent, 2005; Fitzgerald & Laurian-Fitzgerald, 2016; Palmer & Marra, 2004). Jones, Lisciandro, and Olds (2016) demonstrated that using social and emotional learning (SEL) outcomes to inform classroom activities has a positive impact on growth mindset and emotional intelligence. Wise et al. (2004) reported that the implementation of a hands-on design project during the first year can improve a student's Perry level, allowing them to be move beyond Simple Dualism, but this improvement was not maintained throughout the undergraduate experience without continued support. Students reported that certain activities (e.g., co-op, internships, open-ended design projects) (Palmer & Marra, 2004) and classroom interactions (e.g., class discussions, essays, portfolios) helped to develop epistemological beliefs and engage students in deeper learning (Biggs & Tang, 2011; Felder & Brent, 2004b; Schommer & Walker, 1995).

The most common learning strategies that employ self-regulation and reflection are KWL (Know, Want, and Learned) and SQ3R (Survey, Question, Read, Recite and Review) (Vázquez & Nistal, 2013). KWL has been shown to increase content knowledge and provide a concrete measure of learning growth in reading tasks and has been shown to be applicable many different settings within K-12 and undergraduate education (Kennedy, Morton, & Fotecchio, 2015; Shelly, Bridwell, Hyder, Ledford, & Patterson, 1997; Szabo, 2007; Vázquez & Nistal, 2013). For example, KWL was used as a learning strategy in elementary, middle, and junior high school science courses (Shelly et al., 1997) as well as for preservice science teachers in their student teaching (Lotter, 2004). The preservice teachers each completed six KWL exercises as they observed classrooms and an additional 10-15 as they were student teaching. The KWL activities allowed teachers to reflect on the skills they gained during their student teaching, helping them to identify areas where they still needed to develop (Lotter, 2004).

KWL (Ogle, 1986) is a reflective learning exercise that focuses the student on three areas: What I **K**now, What I **W**ant to Know, and What I **L**earned and still need to learn. This is typically a written exercise that can be done individually or in groups (Ogle, 1986). The first step emphasizes the activation of prior knowledge by first brainstorming and then categorizing the known information about a topic. The second step empowers the students to take an active role in their learning by setting specific learning goals for themselves. Ogle (1986) points out that this step "develops the students' own reasons for reading – reading to find answers to questions that will increase their reservoir of knowledge on this topic" (p. 566). For example, if a student wanted to know more about a specific engineering topic, as they are reading, they are more likely to pay attention to that topic. The last step asks the student to check their new knowledge against their learning goals to assess whether or not they have been met. If not, the student makes a plan to find the answers to their lingering questions (Ogle, 1986). This three-step method allows for scaffolding of material as students move through the exercise. For example, "a learner may make some adjustments to the learning goals he or she sets in phase 2 or may reconstruct his/her perception of the task he or she generated in phase 1 once he or she actually engages with learning cognitively and metacognitively in phase 3." (Sha, Looi, Chen & Zhang, 2012, p. 371-372).

The KWL strategy has been shown to increase retention and improve student's independent learning strategies (Shelly et al., 1997). Shelly et al. (1997) explored the effectiveness of this strategy with elementary, middle, and junior high school classrooms. Teachers who used the strategy with their students reported that the KWL structure was effective for reviewing material, providing structure for research projects, and allowing students to make connections with previous material. Teachers also noted an increase in student ability to express complete ideas, an increase in grades, and an increase in student participation in class (Shelly et al., 1997). Although this technique has been used at multiple educational levels, it has been primarily used in K-12 education with promising results. I believe that this technique will be effective in helping first-year engineering students make connections between the material they are currently learning and what has been covered previously, assist them with setting personal learning goals, and allow them to reflect on their learning process. By creating an emphasis in the classroom on setting individual goals and reflecting on them, this should direct students toward a growth mindset.

2.5 Research Questions

Previous research indicates that first-year engineering students likely enter their programs with low, epistemological beliefs (e.g., Simple Dualism) (King & Magun-Jackson, 2009;

Wise et al., 2004). In addition, they are likely to exhibit a similar intelligence belief distribution found in previous research on engineering students with more students having a growth mindset that fixed (Stump et al., 2014). With regard to self-efficacy, previous research indicates that male students have higher self-efficacy regarding engineering topics than female students (Betz & Hackett, 1981; Hutchison et al., 2006; Lent et al., 2008; Marra et al., 2009; Pajares & Miller, 1994; Rogers et al., 2016; Summers & Hrabowski III, 2006).

With knowledge of this literature, I sought to understand how the implementation of a semester-long reflective learning activity impacted the self-efficacy, intelligence beliefs, and epistemological beliefs of first-year engineering students such that 1) self-efficacy increases, 2) growth mindset increases, 3) epistemological beliefs are more sophisticated, and 4) that these changes are more significant in female students. Further, I explored the perceptions that students had regarding the usefulness of the KWL activity to support their learning.

My research questions are as follows:

1. How does the implementation of the KWL exercise impact self-efficacy, intelligence beliefs, and epistemological beliefs in first-year engineering students? What, if any, differences exist between gender?
2. What, if any, are the effects of self-efficacy, intelligence beliefs, and epistemological beliefs on academic performance? What, if any, differences exist between gender?

3. How do first-year students perceive the usefulness of the reflective KWL activity to their learning process?

3 Methods

This study was conducted at Michigan Technological University as part of a first-year engineering course - *ENG1101: Engineering Problem Solving and Analysis*. I used a quasi-experimental design that utilized both quantitative and qualitative data and data analysis. Students were divided into control and experimental groups, with the experimental group receiving the intervention (KWL activity). I started by using a traditional pre-post design to survey student self-efficacy, intelligence beliefs, and epistemological beliefs at the beginning and end of the semester for both the control and experimental groups (quantitative) (Table 3.1). At the end of the semester, the experimental group completed a KWL Reflection Survey, which was both quantitative and qualitative in nature. Initial analysis of this survey, however, revealed that there were two different interaction patterns with the KWL in the experimental group. Because of this, the nature of the research design shifted to a comparison between three groups: control, experimental group 1 (KWL Exposure), and experimental group 2 (KWL Used). Details related to the student population, survey methods, data collection methods, and analyses performed are described below.

Table 3.1 Research Timeline

Beginning of Semester	Intervention*	End of Semester
Pre-Survey • Self-Efficacy • Intelligence Beliefs • Epistemological Beliefs	KWL Activities	Post-Survey • Self-Efficacy • Intelligence Beliefs • Epistemological Beliefs • KWL Reflection*

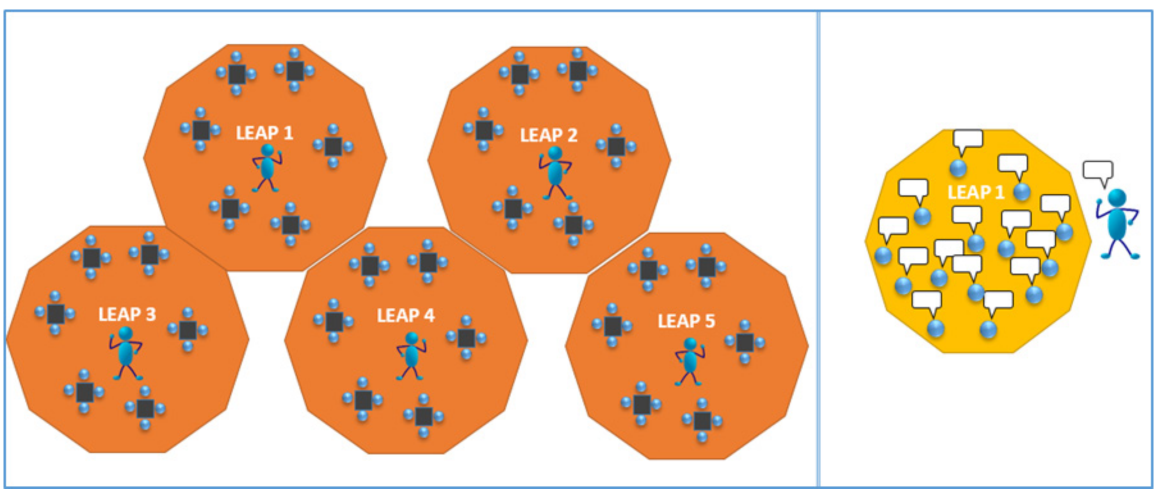
* Implemented in Experimental Group Only

3.1 First-Year Engineering Population

Annually, approximately 1000 first-year engineering students are enrolled in ENG1101 and are randomly assigned to a cohort based on their mathematics placement status (e.g., MA1161, MA1160, MA2160, MA3160 in order of advancing math cohort). These cohorts are comprised of 24 students each, determined by common course enrollment in engineering, mathematics, and a physics lab. First-year engineering students have been using a cohort schedule since 2000, as studies indicated that students enrolled in cohorted courses showed increased performance and more developed teaming skills over non-cohorted students (Hamlin & Hein, 2001; Monte & Hein, 2003).

In the fall of 2017, there were 40 total cohorts of ENG1101 comprised of 14 cohorts of MA1160 students, 16 cohorts of MA1161 students, 8 cohorts of MA2160 students, and 2 cohorts with no or advanced mathematics course enrollment (e.g., MA3160, MA2320/1). Although students are placed initially in cohorts, some students switched one or more of their cohorted classes (engineering, mathematics, or physics). Therefore, while the majority of students are grouped in cohorts, the engineering sections may have a mixture of students from different mathematics enrollments. Past research has shown that students in more advanced mathematics courses (MA2160 or MA3160) typically perform significantly higher on ENG1101 course metrics than students in the lower mathematics courses (e.g., MA1161) (Kemppainen, Fraley, Hein, & Hamlin, 2015).

The first-year engineering curriculum utilizes a flipped environment, where students are responsible for much of their own learning. The course design is structured to accommodate this learning methodology. As part of the course design for ENG1101, five of the cohorts meet simultaneously twice per week in a large group (n = 120) to cover the course material. These five cohorts are typically mixed between math enrollments (e.g., 2-MA1160, 2-MA1161, 1-MA2160). Each of the 40 cohorts then meet separately for an additional hour in a LEAP Session, which is a near-peer facilitated study session designed to assist students with the most challenging course content. As shown in Figure 3.1, the two-hour sessions take place in the engineering classroom with the instructor. For the one-hour session, the students break up into their cohort groups and meet with their LEAP Leader, a student mentor. All students are expected to attend all sessions of the course.



(a) (b)

Figure 3.1 (a). ENG1101 large class environment (n = 120), students meet twice a week for two hours. (b) ENG1101 LEAP environment (n=24), students meet once a week for one hour.

In the 2017-2018 academic year, there were 932 first-year engineering students initially registered for ENG1101 with 225 female students (24.1%) and 707 male students

(75.9%) (H. LaFleur, personal communication, February 27, 2018). Final enrollment by the end of the semester for ENG1101 was 889. Table 3.1 shows the demographic distribution of incoming engineering students for the 2017-2018 academic year. Due to the low numbers of underrepresented minorities, comparisons between ethnic groups were not considered for this study.

Table 3.2 2017 First-Year Engineering Demographics

Race / Ethnicity	n	Percent (%)
Not supplied	10	1.1
American Indian/Alaskan Native	2	0.2
African American	7	0.8
Asian / Asian American	19	2.0
Hispanic / Hispanic American	29	3.1
White / Non – Hispanic	832	89.3
International	7	0.8
Multiracial	26	2.8

3.2 KWL Intervention

This study sought to understand how students' self-efficacy, intelligence beliefs, and epistemological beliefs change over time and with the inclusion of a semester-long reflective learning activity. Following a quasi-experimental design, the KWL exercises were implemented in 20 of the 40 cohorts of ENG1101 this fall. These 20 cohorts were selected due to access to these sections as course instructor (5 cohorts), course co-instructor (5 cohorts), or permission of course instructors (10 cohorts, 2 instructors) (Experimental Group, n = 424). The remaining 20 cohorts of ENG1101 did not utilize the KWL exercises (Control Group, n = 465, 3 instructors). I obtained access to these students through discussion with their course instructors, who aided in the collection of survey data by distributing pre-and post-surveys to their students (discussed in detail below).

All ENG1101 sections were provided with the same course material, in-class activities, homework, and exams. Each week, students in all sections of ENG1101 were provided with an overview of the week's learning objectives. In the experimental group, the KWL exercise was applied to these learning objectives and was used to help students focus their learning and set learning goals for the week. Figure 3.2 shows the KWL exercise implementation plan. The students in the experimental group reviewed the learning objectives and completed the "What I Know" and "What I Want to Know" sections of KWL before the beginning of the first session of the week. After the second session of the week, they reviewed the first two sections and completed the "What I Learned" section.

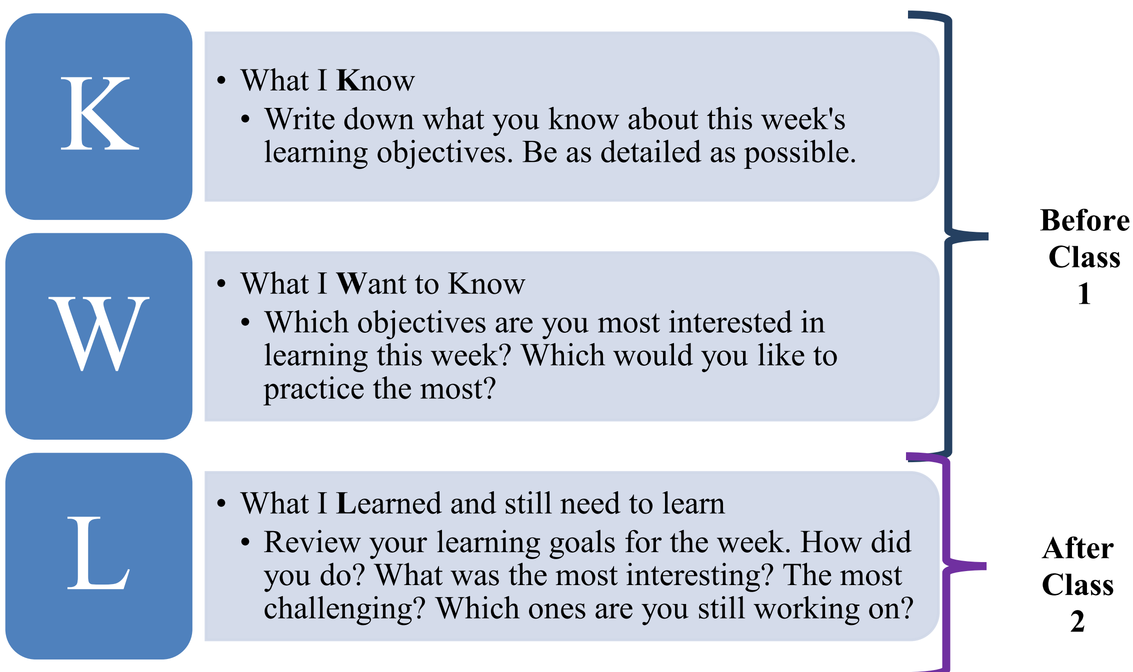


Figure 3.2 KWL Activity Implementation Plan

The KWL exercises were assigned weekly beginning in Weeks 2 – 4 for all students in the experimental group. The first steps of the activity were introduced in Week 2 as an in-class assignment. The instructor explained what the KWL method was and how to complete the activity, which was then completed individually in-class to verify that students understood the process. For this in-class practice, and for future KWLs, the students reviewed the weekly course objectives provided to them and completed the first two columns of the KWL worksheet as shown in Figure 3.3. At the end of the last class period for that week, students were given time to complete the final column "L" of the worksheet. They were provided with the following instructions (Table 3.3) as prompts for completing the final steps of the activity:

Table 3.3 Student Instructions for completing final KWL column

1. As an individual, open your KWL activity you started in class last class period. You should have the first two columns complete. I want you to review these columns
    a. What did you know at the beginning of the week?
    b. What were your goals?
2. Complete the last column of the KWL. What did you learn? Be as specific as possible.
    a. Did you meet your learning goals? Why or why not?
    b. Which learning goal(s), if any, are you still working on?
    c. What was the most interesting thing you learned?
    d. What was the most challenging thing you learned?

At the end of each week, students uploaded their completed worksheets to Canvas, the Learning Management System used by Michigan Tech. A total of nine KWL activities were completed throughout the semester (Weeks 2 – 11). Outside of the first

KWL Worksheet

Name: Team: Section:

Instructions: Use this week's course objectives to complete the first two columns of the table. Be as detailed as possible for each objective. Write what you know already about the topic in column 1, and then set yourself specific learning goals for what you would like to know at the end of the week in Column 2. At the end of the week, you'll complete column 3 and submit your completed worksheet.

What I **Know**	What I **Want** to Know	What I **Learned**

Figure 3.3 KWL Worksheet for students

instance in-class, the remaining KWL activities were assigned and completed outside of class. The first two columns were completed prior to the first session of the week as part of a pre-lesson assignment worth 5 points, and the remaining column was completed at the end of the week as a homework assignment worth 5 points. As the purpose of this study was to determine if the inclusion of these exercises impact self-efficacy, intelligence beliefs, and epistemological beliefs, the four experimental group faculty were instructed to give full credit (5 points) to students who submitted these pre-lesson and homework assignments. Therefore, these activities were not graded on content or effort, but on completion only. Essentially, this was done to determine if students completed the KWL activities throughout the semester or not.

Using the KWL exercise weekly provided students with an opportunity to reflect on their learning throughout the semester, regardless of any feedback (positive or negative) received from course grades. The intention of these exercises was to “prime” students to begin thinking more in the framework of the growth mindset weekly as they set their own learning goals each week; however, no explicit discussion regarding growth mindset ever took place. In addition, this allowed students to face what they do not know and search for the answers each week. This demonstrates the uncertainty of knowledge and that the process for acquiring knowledge comes from different sources, which I hypothesized would impact their epistemological beliefs positively.

3.3 Data Collection

The purpose of this study is to a) determine the effects of the reflective KWL exercise on first-year engineering students' self-efficacy, intelligence beliefs, and epistemological beliefs, b) determine the changes in these measures with respect to gender, c) determine the effects of self-efficacy, intelligence beliefs, and epistemological beliefs on academic performance, and d) determine the student's perception of learning outcomes from the KWL activities. In order to measure these constructs, several instruments were used, all of which are described below.

3.3.1 Assessing Self-Efficacy, Intelligence Beliefs, and Epistemological Beliefs

In order to assess self-efficacy, intelligence beliefs, and epistemological beliefs and how they predict academic performance, several valid and reliable instruments were used: the Longitudinal Assessment of Engineering Self-Efficacy (LAESE), the Implicit Theories of Intelligence Scale (Entity-only), and the Discipline-Focused Epistemological Beliefs Questionnaire (DEBQ) for Mechanical Engineering. The following sections describe each instrument in turn, followed by a description of how data were collected using these instruments.

3.3.1.1 Measuring Self-Efficacy

The Longitudinal Assessment of Engineering Self-Efficacy (LAESE) was used to measure changes in student self-efficacy over the course of the semester. LAESE was developed as part of two NSF grants (HRD 0120642 and HRD 0607081) and measures six subscales: a) engineering career success expectations, b) engineering self-efficacy I,

c) engineering self-efficacy II, d) feeling of inclusion, e) coping self-efficacy, and f) mathematics outcome expectations (AWE, 2017). The questions are on a 7-point Likert-type scale from “strongly disagree” (1) to “strongly agree” (7). The LAESE survey can be used as a whole instrument or using the subscales only (AWE, 2017). For this study, only the self-efficacy subscales were used (Engineering Self-Efficacy I (ESE-I) and Engineering Self-Efficacy II (ESE-II)). The first self-efficacy subscale (ESE-I) focuses on the ability of students to succeed in the educational requirements for engineering (Marra et al., 2009). For example, one of the questions states: “I will succeed (earn an A or B) in my math courses” (AWE, 2017). ESE-II questions focus on student confidence in their abilities (Marra et al., 2009). One such example is “I can complete any engineering degree at this institution” (AWE, 2017). Appendix A contains the engineering self-efficacy questions (AWE, 2017).

3.3.1.2 Measuring Intelligence Beliefs

The Implicit Theories of Intelligence Scale (Entity-only) was used to measure student intelligence beliefs (Dweck, 1999). This survey was designed to measure student mindset about their intelligence. This measure is a four-item scale developed by Dweck (1999) and contains only entity theory statements (alpha = 0.94 -0.98), such that items are phrased toward an entity or fixed mindset belief. For example, one of the questions states: “You have a certain amount of intelligence, and you can’t really do much to change it.” (Dweck, 1999). Students who agree with this statement are said to display a fixed mindset. The entity item only scale was used as studies have shown that in participant’s intelligence beliefs may shift toward incremental (growth mindset) with repeated measures (Dweck, 1999). The use of the entity-only scale reduces the risk of a false-positive shift toward incremental beliefs in student responses. The questions are on a 6-point Likert-type scale from “strongly disagree” (1) to “strongly agree” (6). The complete survey can be found in Appendix B.

3.3.1.3 Measuring Epistemological Beliefs

Epistemological beliefs were measured using the Discipline-Focused Epistemological Beliefs Questionnaire (DEBQ) for Mechanical Engineering by Hofer (2000). This 18-item survey measures four factors of epistemological and intellectual beliefs: believing in certain, simple knowledge (Certainty Beliefs), believing that personal experience is the justification for knowing something (Justification beliefs), believing that authorities are the source of knowledge (Authority Beliefs), and believing that the truth can be obtained (Truth Beliefs) ($0.71 < \alpha < 0.82$) (Hofer, 2000). The complete instrument can be found in Appendix C. The items are rated on a 5-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5). Higher scores on the instrument indicate lower, less sophisticated epistemological beliefs, which correspond to lower Perry Levels (Hofer, 2000). The DEBQ survey instructions from Hofer (2000) remind students that the statements are about engineering in general. These instructions prompt students to mentally replace general statements such as “the field” and “this subject” with “engineering” as students complete the survey.

3.3.1.4 Measuring Numeracy

In addition to the previous three measures, numeracy was used to aid in the prediction of academic performance for Research Question 2. Numeracy provides a measure of the cognitive ability of the students in terms of their decision-making ability. Numeracy was used to determine if general mathematical ability (as determined by mathematics placement) or numeracy skills add significantly to the prediction of academic performance. This test has been shown to be a significant predictor of skilled decision making, more so than general intelligence (Cokely et al., 2012).

I used the 4-item electronic version of the Berlin Numeracy Test (www.riskliteracy.org), shown in Appendix D, to provide a measure of cognitive ability of the students. For each of the four questions, the participants are given a scenario and are asked to determine the percent or probability of the scenario occurring. In general, individuals who answer more questions correctly are more numerate and have more developed decision-making abilities. The version of the Berlin Numeracy test used (computer, non-adaptive test, with 4 items) is most similar to the standardized paper-pencil format validated by Cokely et al. (2012). This test is scored with a binary “correct” or “incorrect” awarded to each question for a maximum of 4 points. The psychometric properties of this scale are M = 1.6, SD = 1.21, which indicates that for a general population there is an average score of 1.6 out of 4 items correct with a standard deviation of 1.21 (Cokely et al, 2012).

3.3.1.5 Pre/Post Data Collection Methods

The data described above were collected in a traditional pre/post fashion in ENG1101. The consent form, LAESE self-efficacy questions, the Implicit Theories of Intelligence Scale questions, and the DEBQ questions were bundled in a single Survey Monkey survey. A link was provided to all ENG1101 course instructors who forwarded this to their students via email; this assured that students in both the experimental and control groups had access to the survey. For the experimental group and some of the control group (n = 30 cohorts, 660 students), the survey was given to the students as an assignment worth 10 points. For the remaining control group cohorts (n = 10 cohorts, 229 students), the course instructor did not want to make this a homework assignment, so the survey was simply sent out to the students via email. To ensure voluntariness, the survey was structured so that if a student consented to the research, they were immediately prompted with the rest of the survey. If they did not consent, they were directed to enter their name, course, and instructor and submitted the survey. In this fashion, all students had the opportunity to earn credit for the assignment, but only those students who consented to the research and completed the entire survey earned 10 points. This ensured voluntariness of participants, but also encouraged higher participation rates as the majority of the students were given this as an assignment.

Initial data collection on this survey started Week 2 of the semester and was completed by Week 4. A total of 519 students consented to the study and completed the pre-survey for a response rate of 58.4%. As the Berlin Numeracy Test was not approved by Michigan Tech’s Institutional Review Board until later in the semester, it was made available to students during weeks 7 and 8 of the semester via a Survey Monkey survey sent out by their course instructor. The same method to ensure voluntariness were used in this survey as described above. A total of 655 students (73.7% response) completed the pre-survey for numeracy.

The post-survey administered through Survey Monkey was identical to the pre-survey, but without the consent form and with the inclusion of the Berlin Numeracy Scale questions. The post-survey was assigned as a 10-point homework assignment in all sections of ENG1101 and was available for students to complete Weeks 13-14 of the semester. A total of 822 students completed the post survey for a 92.5% response rate. Of these results, 244 did not consent to the research initially, so their responses were not considered for analysis. In addition, after initial analysis of the pre- and post-surveys, it was found that several of the students did not answer the questions truthfully (as evidenced by reverse-scored questions) or thoughtfully (as evidenced by time spent on survey (< 2min)). A total of 22 student responses were removed for one or both reasons.

3.3.2 Understanding Student Perceptions of KWL

In order to understand students' perception of the KWL exercises, quantitative and qualitative data were obtained from students in the experimental group (n = 424) from the KWL Reflection Survey as described below.

3.3.2.1 KWL Reflection Survey Data Collection

The KWL Reflection Survey was used to provide a quantitative measure of the quantity of KWL surveys completed as well as a quantitative measure of the perceived effort used by students. In addition, the survey provided a qualitative measure for the student perceptions of learning and attitudes toward learning from using the KWL activities. The KWL Reflection Survey was assigned to students in the experimental group at the end of the semester. This survey was administered via the Canvas Learning Management System. Students in the experimental group first reviewed their submissions to the weekly KWL exercises and then completed the KWL Reflection Survey (Table 3.4).

Table 3.4 End of Term KWL Reflection Survey

Questions
1. How many KWL assignments did you complete?
2. How many KWL assignments did you start, but not complete (i.e., no L)?
3. On a scale of 0 to 100%, how much effort and thought did you put into completing the KWL assignments?
4. On which stage(s) (K, W, or L) did you provide the most detail and why?
5. In reviewing your KWL responses, what learning goals did you achieve this semester? Which are you still working on?
6. In what ways, if any, do you feel that the KWL exercises impacted your learning this semester?
7. In what ways, if any, do you feel that the KWL exercises impacted your attitudes towards learning this semester?
8. Is KWL a learning method you think you might use in the future and why?
9. What could be done to make the KWL activity more useful for your learning?
10. If you have additional thoughts you would like to share on how the KWL activity was used in ENG1101 this semester, please do so here.

The first four questions were quantitative in nature and were meant to determine the number of KWL assignments each student completed and where they focused their efforts; one of the consequences of administering this survey was discovering that this group was actually comprised of two groups (described in more detail below). This was because there were discrepancies on how many KWL activities were completed by students and how much effort students used to complete these activities throughout the semester. The remaining questions of the survey (5-10) were intended to determine the effects of the KWL activity with respect to student perceptions of goal achievement, impact on learning, attitudes towards learning, and future use of the KWL method. The survey was set up as a 10-point survey assigned to the students in the experimental group as homework. There were 353 students who responded to this survey for a response rate of 83.3%.

3.4 Data Analysis

As noted previously, not all of the students who consented to the research completed all of the surveys. In order to compare the pre- and post-test results with the same students, it was important to consider only complete sets of data from students. Only 410 students (46.1%) of the ENG1101 students consented to the research, completed all the pre and post-test measures, and were included in the final analysis. After initial analysis of the results from the KWL Reflection Survey (described below), it became apparent that there were differences in how students in the experimental group participated in the KWL intervention. This changed my experimental design from a purely quasi-experimental design to include an ex post facto approach. The ex post facto approach is used when research subjects exhibit a certain behavior or characteristic that warrants further investigation (Kirk, 2013).

In this case, I used a retrospective ex post facto approach, as the difference in utilization of the KWL activities within the experimental group was not determined before the study started. I chose to use the case-control study retrospective technique. This study type splits the subjects into cases, which are “then compared in terms of their previous exposure to the independent variable” (Kirk, 2013, p. 10). In this case, I used a case-control ex post facto approach to divide the experimental group into two subgroups: a) those students who used the KWL (“KWL Used”) and b) those students who were exposed to the KWL exercise, but did not participate fully (“KWL Exposure”). This classification was based on students’ self-reported effort in the KWL activities (KWL Reflection Survey Question 3); the traditional academic measure of satisfactory (70% or better) was used to split the groups. Therefore, those students putting 70% or more self-reported effort into the activities were classified as “KWL Used” and students with less than 70% effort were classified as “KWL Exposure.” The distribution of students into each test group is found in Table 3.5 below.

Table 3.5 Sample distribution of complete pre-post survey results

Control Group (n = 163)		KWL Exposure (n = 140)		KWL Used (n = 107)	
Math Cohort	Gender	Math Cohort	Gender	Math Cohort	Gender
MA1160 (n = 44)		MA1160 (n = 32)		MA1160 (n = 31)	
MA1161 (n = 39)	Male (n = 120)	MA1161 (n = 40)	Male (n = 95)	MA1161 (n = 28)	Male (n = 74)
MA2160 (n = 40)	Female (n = 43)	MA2160 (n = 32)	Female (n = 45)	MA2160 (n = 25)	Female (n = 33)
MA3160 (n=30)		MA3160 (n=31)		MA3160 (n=12)	

3.4.1 Research Question 1

As mentioned previously, I used a quasi-experimental design to address Research Question 1, but instead of comparing between two groups, I compared the three groups described above. I measured the changes in self-efficacy, intelligence beliefs, and epistemological beliefs within and between test groups (control, KWL Exposure, KWL Used) and mathematics cohort (MA1160, MA1161, MA2160, MA3160), as well as within and between test groups (Control, KWL Exposure, KWL Used) and gender (female, male). Due to the low sample size three-way interactions between test group, mathematics cohort, and gender were not performed. For each group, the dependent variables were student self-efficacy, intelligence beliefs, and epistemological beliefs. The independent variable was the use of or exposure to the KWL reflective activity. Quantitative data were collected through the use of pre- and post-assessments described in the previous section.

As most of the results for epistemological beliefs in literature were broken into categories (e.g., certainty beliefs, knowledge acquisition), it was important to analyze the DEBQ epistemological belief scales separately in order to compare results with previous literature. In addition, since only the LAESE Engineering Self-Efficacy scales were used instead of the complete instrument, these scales were analyzed separately. For each scale or subscale of self-efficacy, intelligence beliefs, and epistemological beliefs, I calculated an overall score by adding up the total responses for each survey question in that scale. This created composite, continuous variables for each subscale to use in further analyses such as t-tests and ANOVAs, which require continuous variables. These composite, continuous variables and their expected values are summarized below.

For the Self-Efficacy-I subscale, the total composite score ranges from 5 (1 = Strongly Disagree on all 5 subscale questions) to 35 (7 = Strongly Agree on all 5 subscale questions). The Self-Efficacy II subscale composite score ranges from 6 to 42 points. The Intelligence Beliefs Scale is a four question scale on a 6 point Likert Scale so the composite score ranges from 1 to 24 points. The DEBQ scale is measured on a 5-point Likert Scale and each subscale was analyzed separately. The Certainty Beliefs subscale composite score ranges from 8 to 40 points, the Authority and Justification subscale composite scores range from 4 to 20 points, and the Truth subscale composite score ranges from 2 to 10 points.

In addition to creating a composite score for the intelligence beliefs scale, students were classified based on their responses to this survey as having a growth, mixed (growth), mixed (fixed), or fixed mindset. Students who disagreed or strongly disagreed (scored 4 – 8 points) on the entity-only (fixed) intelligence beliefs survey were classified as having a growth mindset. Students who scored a 9 – 12 on this scale (averaging a "slightly disagree" response) were classified as having a mixed mindset, but leaning toward growth. Students who scored a 13 – 16 on the scale on average slightly agreed with all the scale items. These students were classified as mixed but leaning towards fixed mindset. Finally, students who agreed or strongly agreed with these items (scoring 17 – 24 points) were classified as having a fixed mindset.

The collapsing of scales left me with six separate scores for each participant: two self-efficacy subscale scores (ESE-I and II), an intelligence beliefs scale score, and four epistemological belief subscale scores (certainty, justification, authority, and truth). Prior to conducting statistical tests, each of these scores needed to be checked for assumptions for using parametric statistics. Using the Explore function of SPSS, I reviewed the normality and variance of each scale. Homogeneity of variances existed, as assessed by Levene's test of homogeneity of variances ($p > 0.05$). By inspection of the histograms, the majority of the data appeared to follow a normal distribution. Data from the control and experimental groups for both self-efficacy measures were positively skewed, which may reflect a ceiling effect in the data. In addition, the intelligence beliefs and epistemological certainty beliefs scales were negatively skewed. Although these data do not follow a normal distribution, the skew is the same for both test groups. Therefore, I considered the assumptions to be met.

I initially compared pre-test results for self-efficacy, intelligence beliefs, and epistemological beliefs scores between the control and experimental groups using a one-way ANOVA to determine if significant differences existed between groups or if the variation between groups were similar. For all analyses, statistical significance was defined at the $p < 0.05$ level. No significant differences were found between the control and experimental groups on intelligence beliefs and the certainty, authority, and truth subscales of the DEBQ ($p>0.05$), meaning that students in the control group and experimental groups could be considered as part of the same population. However, there were significant differences between the LAESE ESE-I and II subscales and DEBQ epistemological justification belief subscale results in the test groups ($p<0.05$), meaning that these differences needed to be controlled for in further analyses. I then completed a one-way ANOVA to search for gender differences and differences between mathematics cohorts as research has indicated differences between these two groups. As expected, investigating differences by gender revealed significant differences between male and female students on ESE-I and the certainty beliefs subscales ($p<0.05$). Additionally, there were significant differences between the mathematics cohorts on the LAESE ESE-I and II subscales and the intelligence belief scale ($p<0.05$), which needed to be controlled for in further analyses.

Due to the need to control for pretest differences on several measures, different parametric tests were used to analyze the pre-post differences between groups (Table 3.6). First, I used a three-way mixed ANOVA (Between – Between – Within) to compare pre-post differences between 1) test group and gender and 2) test group and mathematics cohort, as well as the interaction between these groups (Table 3.6) for those variables where no pretest differences occurred. I used a three-way mixed ANCOVA (Between – Between – Within) to compare pre-post differences between test group and gender (or mathematics cohort) and the interaction between these groups for those variables where pretest differences occurred. Bonferroni post-hoc tests were used for both ANOVA and ANCOVA tests. I did not test for three-way interactions (test group and gender and mathematics cohort) due to the low sample size, limiting my ability to determine the true significance of the results. In particular, with a low sample size, any outlying data will significantly affect the results increasing the probability of a Type I or Type II error.

Therefore, I looked at main effects due to gender, mathematics cohort or test group and two-way interactions (test group * gender, test group * mathematics group) only.

The three-way mixed ANOVA was used only when the initial analysis of the pretest results did not indicate significant differences between groups. For example, this test was used when comparing pre/post differences between the test groups on intelligence beliefs and the certainty, authority, and truth subscales of the DEBQ. For those groups where significant differences were found in the pretest results, I used an ANCOVA test, which used the pretest values as a co-variate to test each subscale independently. For example, to test for differences on post-test self-efficacy scales (ESE-I and II) in the test groups, I used a separate ANCOVA test for each self-efficacy subscale. To test for ESE-I, the pre-test ESE-I subscale score was added as the co-variate in the ANCOVA test.

Table 3.6 Pre/post analyses of Self-Efficacy, Intelligence Beliefs, and Epistemological Beliefs (○ = ANOVA, ● = ANCOVA)

Dependent Variable	Main Effects			Two-way Interactions	
	Group	Gender	Math	Group * Gender	Group * Math
Engineering SE- I	●	●	●	●	●
Engineering SE - II	●	○	●	●	●
Intelligence Beliefs	○	○	●	○	●
DEBQ - Authority	○	○	○	○	○
DEBQ - Certainty	○	●	○	●	○
DEBQ - Justification	●	○	○	●	●
DEBQ - Truth	○	○	○	○	○

3.4.2 Research Question 2

To address my second research question (effects on academic performance), I used multiple regression to determine the unique contributions of the LAESE self-efficacy measures (ESE-I and ESE-II), intelligence beliefs, DEBQ epistemological beliefs, and Berlin Numeracy scales and subscales on academic performance (first-semester GPA and ENG1101 course performance). Post-survey scale and sub-scale values were used in the analysis as these values represent the KWL intervention results. Gender and mathematics cohort were controlled for by transforming these variables into dummy variables to insert into the multiple regression analysis. I used the “enter” multiple regression method in SPSS to determine which, and by how much, each independent variable affects academic performance. Using this technique, I have control over the analysis and was able add any or all the independent variables to look at individual contribution toward the overall prediction of performance. I used the results from the coefficient matrix in the output to get the overall regression equation, with the R-squared value providing the goodness-of-fit of this model. Multiple iterations of this process were done to find which variables in which combination provide the best prediction for academic success.

3.4.3 Research Question 3

To determine how first-year students perceive the usefulness of the reflective KWL activity to their learning process, I analyzed the qualitative and quantitative data from the end of term KWL Reflection Surveys for all students in the large experimental group (n = 247). All of the survey data was downloaded from Canvas and imported into Excel. Descriptive statistics were calculated for the number of students who completed KWL activities, their self-reported effort used to complete the KWL activities, and which stage (K, W, or L) students thought they provided the most detail. As mentioned previously, the second item (effort used to complete KWL) was used to inform the ex post facto reflective case-control study, which divided the experimental group into KWL Exposure and KWL Used.

Results from the KWL Reflection Survey on student reported impact on learning and impact on attitudes toward learning were analyzed using qualitative methods. I drew a convenience sample from the experimental group that included the five cohorts (n=116) that I instructed. The qualitative responses from this sample for each question were printed and coded initially as positive, negative, or neutral to obtain a frequency count of how students perceived the activity in terms of impacts on their learning. A similar process was used to quantify the student reported effects on attitudes towards learning after using the KWL activities into positive, negative, or neutral changes in attitudes. I graphically compared the frequencies of these responses in the two experimental groups (KWL Used and KWL Exposure) to determine if the students rated the activity differently between groups. Example responses for each of these categories are described below (Table 3.7).

Table 3.7 Characteristic Student Responses to KWL Reflection Survey

Category	**Impact on Learning**	**Attitudes toward Learning**
Positive	“*It made me prioritize my learning for ENG1101.*”	“*I think the KWL pushed me to try and achieve the goals for the week because I didn’t want to feel like I was falling behind in the class.*”
Neutral	“*In no ways did KWL impact my learning this semester.*”	“*No they did not impact my attitude at all.*”
Negative	*“It wasted my time, leaving me less time to study and work on homework.”*	*“They made me dread going to class because I knew I had to complete them and it was busy work to have to do outside of class when I should have been doing other homework.”*

In addition to quantifying the qualitative responses, the qualitative responses from this sample for each question were printed and coded using an inductive, open coding approach (Merriam & Tisdell, 2015) to perform a more in-depth qualitative analysis. Open coding was developed as part of grounded theory methods and is typically used at the beginning of the coding process when you wish to be "open" to all possibilities your data may present (Saldaña, 2015). Secondary, focused coding was then used to "focus" the codes and to develop themes and categories (Saldaña, 2015). These themes and categories then led to an understanding of how the KWL exercise was used in the learning process and how it impacted student attitudes towards learning.

Figure 3.4 demonstrates this coding process. The first step in this process was to read the data and create codes using open coding methods. Codes are typically words or short phrases used to capture the essence of the data (Saldaña, 2015). For example, a student response for how the KWL activities impacted their learning was "*They set learning goals for me to achieve*" was coded as "**goals**." The data were read four times to first read the data, code the data using open coding, confirm the codes through a second pass pf the data, and to group the codes (focused coding). This grouping, or categorizing, is the next step in Figure 3.4. In this step, codes were grouped together into larger categories (e.g., focused coding), which then become themes, and finally assertions as to how students perceived the KWL impact on their learning and attitudes towards learning. To ensure that these assertions were valid for the entire experimental group, additional sections were reviewed to see if any additional themes or data emerged. As no additional themes were discovered, it was concluded that saturation of the data was reached.

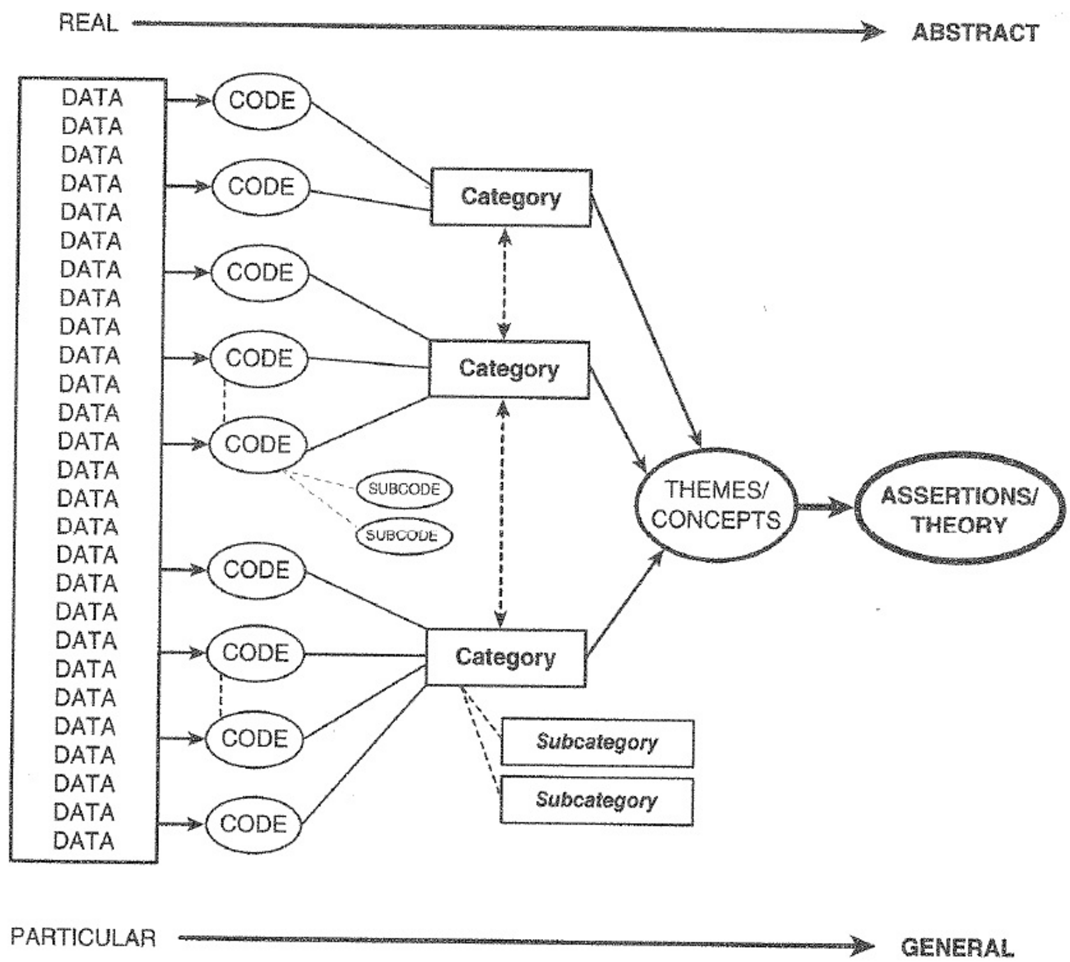


Figure 3.4 A streamlined codes-to-theory model for qualitative inquiry (Saldaña, 2015, p. 14)

4 Results

This thesis addressed three main research questions:

1. How does the implementation of the KWL exercise impact self-efficacy, intelligence beliefs, and epistemological beliefs in first-year engineering students? What, if any, differences exist between gender?
2. What, if any, are the effects of intelligence beliefs, epistemological beliefs, and self-efficacy on academic performance? What, if any, differences exist between gender?
3. How do first-year students perceive the usefulness of the reflective KWL activity to their learning process?

The first section of Chapter 4 (Section 4.1) addresses Research Question 1. I present the results from the pre-post comparisons of self-efficacy, intelligence beliefs, and epistemological beliefs between test group and gender. Section 4.2 focuses on Research Question 2 and presents the results of the two hierarchical multiple regression analyses used to predict ENG1101 course performance and overall GPA. Section 4.3 presents the quantitative and qualitative data from the KWL reflection survey to address Research Question 3. The final section of this chapter (Section 4.4) presents an evaluation of an alternative ex post facto grouping of the experimental group.

4.1 Research Question 1

4.1.1 Self-Efficacy

Engineering Self- Efficacy was measured using the two self-efficacy scales on the LAESE instrument. Using an independent samples t-test, I found statistically significant differences in the pretest results on the LAESE Engineering Self-Efficacy I Scale (ability to succeed in academic courses) between gender ($p = 0.012$). The results indicated that incoming male students reported a higher initial Engineering Self-Efficacy-I than their female counterparts. In addition, statistically significant results were found between test groups and mathematics cohorts using a one-way ANOVA (Table 4.1). Students in the control group indicated lower incoming ESE-I scores than the students in the KWL Exposure group. Although the one-way ANOVA between mathematics cohorts indicated significant differences ($p=0.045$), neither the Bonferroni nor Tukey post-hoc confirmed this to the 0.05 level of confidence. The results do seem to indicate general trend that students in the lower levels of mathematics (MA1160 and MA1161) display lower confidence in their ability to succeed in their academic courses than students in the higher mathematics cohort (MA3160).

These results were similar to the self-efficacy pre-test results on the LAESE Engineering Self-Efficacy II scale (confidence in abilities). Statistically significant differences were found between mathematics cohort and test group using a one-way ANOVA (Table 4.1). No significant differences were found between genders on this scale. As with the ESE-I initial results, students enrolled in MA3160 reported higher incoming ESE-II scores than students in MA1161. Looking at test group, students in the

KWL Exposure group demonstrated higher initial ESE-II scores than both the control and KWL Used groups.

Table 4.1 Incoming Self-Efficacy beliefs of First-Year Engineering Students

Scale	Group	Comparison Groups (1, 2)	ΔMean (1-2)	p
ESE - I	Gender	Male, Female	1.05	0.024*
	Math Cohort	MA1160, MA3160	-1.36	0.120
		MA1161, MA3160	-1.36	0.126
	Test Groups	Control, KWL Exposure	-1.46	0.003*
ESE-II	Test Groups	Control, KWL Exposure	-1.63	0.005*
		KWL Used, KWL Exposure	-1.44	0.037*
	Math Cohort	MA1161, MA3160	-2.08	0.012*

*p < 0.05, ** p < 0.001

Due to the initial differences in pre-test results on the ESE-I scale with regard to gender, mathematics cohort, and test group, I tested for significant changes in post ESE-I values with respect to these independent variables using an ANCOVA test with the pre-test ESE-I score as the covariate. The results of this analysis are summarized in Table 4.2. There were no statistically significant differences in post-test results between gender, mathematics cohort, or test groups ($p > 0.05$). Additionally, there were no significant two-way interactions present. While there were no significant changes, there was a general decrease in ESE-I scores between the pre- and post-test in all groups except the MA3160 group. In addition, at the end of the semester male students continued to demonstrate higher ESE-I values than their female counterparts.

Table 4.2 Changes in Engineering Self-Efficacy I between groups

Dependent Variable	Group	(df, Error)	F	p	partial η^2
Engineering Self-Efficacy I	Gender	(1, 340)	0.467	0.495	0.001
	Math	(3, 340)	2.239	0.083	0.019
	Test	(2, 340)	1.252	0.287	0.007
	Gender * Test	(2, 340)	0.567	0.568	0.008
	Math * Test	(6, 340)	0.439	0.852	0.008

*p < 0.05, ** p < 0.001

As significant differences existed in the pretest results for the LAESE Engineering Self-Efficacy II scale for both the test groups and mathematics cohort, an ANCOVA was performed that used the ESE-II pre-test score as the covariate. The results indicate statistically different post-test results between the test groups (Table 4.3). At the end of the semester the ESE-II trends observed at the beginning switched, with students in the control group indicating higher ESE-II scores than the students who were in the KWL Exposure group ($\Delta M = 1.297$, $p=0.039$, 95% CI [0.048, 2.545]). This finding has a small effect size (partial $\eta^2 = 0.018$). Students in the KWL Used group also showed higher ESE-II scores than the KWL Exposure group, although these differences were not statistically significant.

In addition, there appear to be significant differences between mathematics groups, but the Bonferroni post-hoc tests do not confirm these results. In general, students in MA1161 continued to demonstrate the lowest ESE-II values and students in MA3160 demonstrated the highest ESE-II values. As no significant differences in ESE-II scores were detected between male and female students, the pre-post differences in ESE-II with respect to gender was analyzed using a two-way mixed ANOVA. There were no significant differences between male and female students on post ESE-II scores, although female students showed lower ESE-II scores at the end of the semester than their male counterparts. Similar to the results for ESE-I, there were no significant changes between the pre- and post-test scores in ESE-II within test groups, mathematics cohort, or gender, although all groups except the MA3160 group showed a non-significant decrease in ESE-II scores.

Table 4.3 Changes in Engineering Self-Efficacy II between groups

Dependent Variable	Group	(df, Error)	F	p	partial η^2
Engineering Self-Efficacy II	Gender	(1, 396)	1.119	0.291	0.003
	Math	(3, 348)	2.754	0.042	0.023
	Test	(2, 348)	3.146	0.044*	0.018
	Gender * Test	(3, 348)	0.085	0.918	0.000
	Math * Test	(6, 348)	1.842	0.090	0.031

*p < 0.05, ** p < 0.001

4.1.2 Intelligence Beliefs

Initial analysis of the Implicit Theories of Intelligence Scale showed that incoming first-year students begin ENG1101 primarily with a growth mindset (Figure 4.1). Approximately 47.8% (n = 196) of students disagreed or strongly disagreed with the entity-only (fixed) intelligence beliefs survey and were thus classified as having a growth mindset. An additional 21.7% (n = 89) were classified as having a mixed mindset, but leaning toward growth. Only 13.7% (n = 56) students were classified as fixed mindset initially with an additional 16.1% (n = 66) classified as mixed but leaning towards fixed. Initial analysis using a one-way ANOVA also indicated close to significant differences between mathematics cohorts with students in MA1161 displaying more growth mindset than MA1160 ($\Delta M = 1.69$, $p=0.051$).

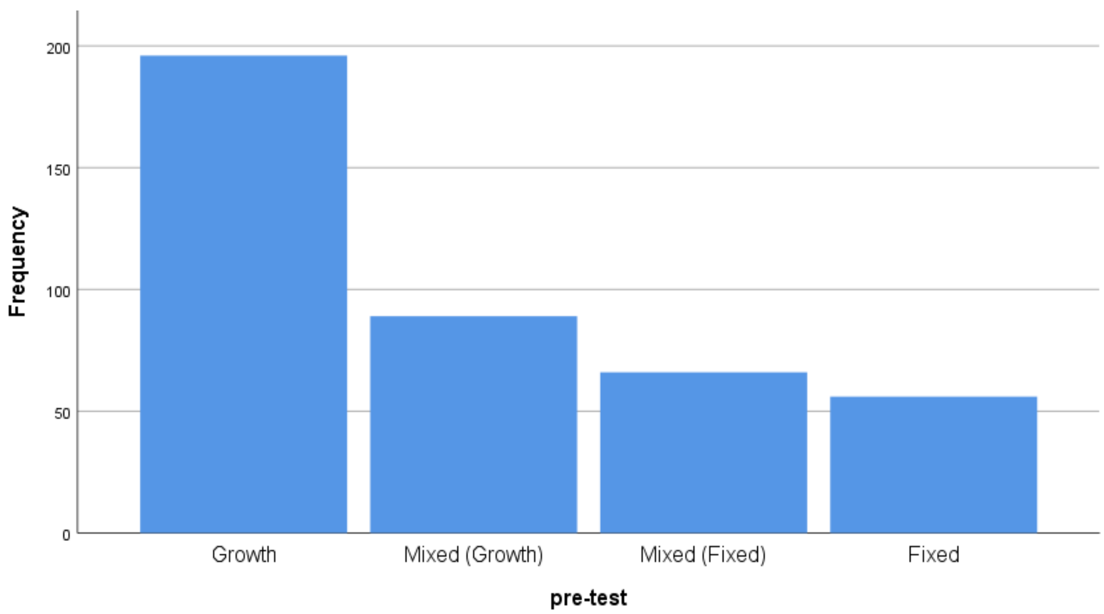


Figure 4.1 First-year Engineering Student Incoming Intelligence Beliefs

A three-way mixed ANOVA between gender, time, and test groups revealed no significant differences in intelligence beliefs. However, the changes between male and female students in intelligence beliefs approached significance ($p = 0.064$), with female students having a greater tendency towards a growth mindset toward the end of the semester. This relationship is depicted in Figure 4.2 below. By the end of the semester, 47.1% of female students were classified as growth mindset as compared to 43.3% of male students. In contrast, only 9.9% of female students were classified as fixed mindset at the end of the semester with 18.3% of male students classified as fixed. No significant differences were found within the test groups, gender, or mathematics cohorts over time ($p > 0.05$).

Table 4.4 Changes in Intelligence beliefs between groups

Dependent Variable	Group	(df, Error)	F	p	partial η^2
Intelligence Beliefs	Gender	(1, 401)	3.461	0.064	0.009
	Math	(3, 356)	0.475	0.700	0.004
	Test	(2, 401)	1.734	0.178	0.009
	Gender * Test	(2, 401)	0.829	0.437	0.004
	Math * Test	(6, 356)	0.440	0.852	0.007

*p < 0.05, ** p < 0.001

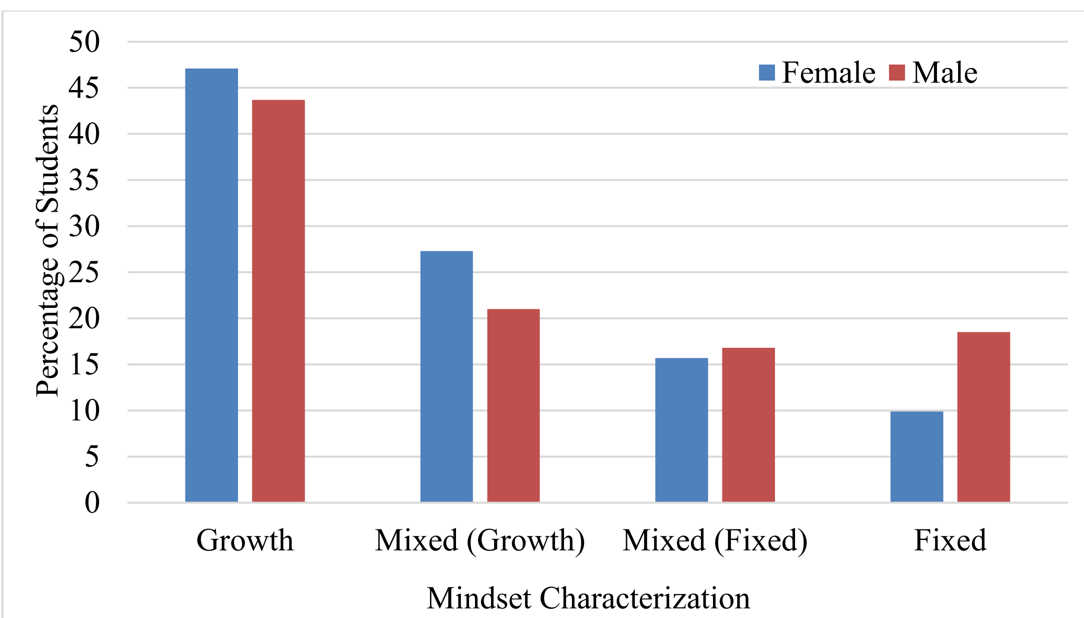


Figure 4.2 First-year Engineering Student Intelligence Beliefs by Gender (Post survey)

4.1.3 Epistemological Beliefs

Pre-test data on the DEBQ epistemological beliefs scale showed significant differences between pre-test scores by gender on the certainty subscale with male students group having higher (less sophisticated) certainty beliefs than their female counterparts (ΔM = 1.178, p=0.002). An ANCOVA was used to test for differences between pre/post certainty beliefs, gender, and the two-way interaction between test groups and gender (Table 4.5). The pretest scores for certainty beliefs served as the covariate in this test. To test for changes in pre/post certainty beliefs between test group and mathematics cohort and the two-way interactions between them, I used a two-way mixed ANOVA. The results are shown in Table 4.5 below. Significant differences were found using a Bonferroni post-hoc test between test groups with students in the KWL Used group demonstrating higher certainty belief scores than the KWL Exposure group (ΔM = 1.253, p=0.020, 95% CI [0.150, 2.356]), indicating lower sophistication of certainty beliefs in the KWL Used group, although this represents a small effect (partial η^2 = 0.021).

Table 4.5 Changes in Epistemological Certainty beliefs between groups

Dependent Variable	Group	(df, Error)	F	p	partial η^2
	Gender	(1, 337)	0.186	0.667	0.001
	Math	(3, 350)	0.303	0.823	0.003
Certainty	Test	(2, 350)	3.734	0.025*	0.021
	Gender * Test	(2, 337)	0.225	0.799	0.001
	Math * Test	(6, 350)	1.128	0.346	0.019

*p < 0.05, ** p < 0.001

There were significant initial differences between test groups on the justification scale (Table 4.6) with students in the control group indicating higher scores (less sophisticated justification beliefs) than students in the KWL Exposure group ($\Delta M = 0.620$, $p=0.021$, 95% CI [0.070, 1.169]). An ANCOVA test was used to test for differences between pre/post justification beliefs, test groups and two-way interactions between test groups and gender and test groups and mathematics cohorts. A three-way mixed ANOVA was used to determine the main effects on justification between genders and mathematics cohorts. No statistically significant main effects or two-way interactions were observed for the justification subscale. In general, only the MA1161 mathematics cohort increased in their justification beliefs over time, but these results were not significant. The other mathematics cohorts demonstrated a non-significant decrease in these beliefs over time.

Table 4.6 Changes in Epistemological Justification Beliefs between groups

Dependent Variable	Group	(df, Error)	F	p	partial η^2
Justification	Gender	(1, 355)	3.105	0.079	0.009
	Math	(3, 355)	0.876	0.453	0.007
	Test	(2, 339)	0.171	0.843	0.001
	Gender * Test	(2, 339)	0.856	0.426	0.005
	Math * Test	(6, 339)	1.907	0.079	0.033

*$p < 0.05$, ** $p < 0.001$

No significant results were found from the three-way mixed ANOVA between groups for the Authority and Truth epistemological belief scales (Table 4.7). In general, there was a non-significant increase in Authority beliefs scale scores over time within test groups, MA2160 mathematics cohort, and male students. This indicates a lower sophistication authority belief in these groups. Within groups on the truth scale, male students again indicated lower sophisticated beliefs at the end of the semester along with MA1160, MA1161, and MA2160 mathematics cohorts as well as the control and KWL Exposure groups. Female students, students enrolled in MA3160, and students in the KWL Used group demonstrated more sophisticated beliefs at the end of the semester on the truth scale, but these results were not significant.

Table 4.7 Changes in Epistemological Authority, Justification, and Truth Beliefs between groups

Dependent Variable	Group	(df, Error)	F	p	partial η^2
Authority	Gender	(1, 348)	1.108	0.293	0.003
	Math	(3, 348)	0.415	0.742	0.004
	Test	(2, 348)	0.144	0.866	0.001
	Gender * Test	(2, 348)	1.903	0.151	0.011
	Math * Test	(6, 348)	1.351	0.234	0.023
Truth	Gender	(1, 351)	0.084	0.772	0.000
	Math	(3, 351)	0.301	0.825	0.003
	Test	(2, 351)	0.033	0.968	0.000
	Gender * Test	(2, 351)	0.143	0.867	0.001
	Math * Test	(6, 351)	1.901	0.080	0.031

*p < 0.05, ** p < 0.001

4.2 Research Question 2

To answer Research Question 2 and to determine the effects of self-efficacy, intelligence beliefs, epistemological beliefs, and gender on academic performance, a hierarchical multiple regression was performed by testing each scale or subscale score in the regression model. Only the post-test scale scores were used in this analysis. As many studies indicate that self-efficacy is a significant predictor of academic success (e.g., Lent, Brown, & Larkin, 1986; Marra et al., 2009), these analyses were run to determine if any of these scale values (intelligence beliefs, epistemological beliefs, and gender) significantly add to the prediction of academic success in addition to self-efficacy. Numeracy and mathematics cohort were also included in this analysis to determine if decision making skills and/or mathematics ability (as determined by mathematics placement) are additional predictors of academic performance. The numeracy scores of first-year engineering students were M = 1.91, SD = 1.003. As the psychometric properties of this scale are M = 1.6, SD = 1.21 (Cokely et al, 2012), this indicates that first-year engineering students have consistently more developed decision making abilities than the general population.

As expected, the self-efficacy scales are significantly correlated with each other (Table 4.8). However, the DEBQ Justification scale was not significantly correlated with the other DEBQ subscales. This implies that the Justification subscale (i.e., believing that personal experience is the justification for knowing something) is independent of students' belief in certain and simple knowledge (Certainty Beliefs), beliefs that authorities are the source of knowledge (Authority Beliefs), and beliefs on how truth can

Table 4.8 Summary of Intercorrelations for Self-Efficacy, Intelligence Beliefs, Epistemological Beliefs, Numeracy, and Performance Measures

Measure	1	2	3	4	5	6	7	8	9	10
1. ESE-I	--	0.665**	-0.035	-0.089	0.144*	0.175**	-0.035	0.229**	0.398**	0.397**
2. ESE - II	0.665**	--	-0.023	-0.094	0.141*	0.138*	-0.047	0.156*	0.329**	0.339**
3. Mindset	-0.035	-0.023	--	0.050	0.213**	0.002	0.291**	-0.056	-0.037	-0.003
4. Justification	-0.089	-0.094	0.050	--	-0.039	-0.079	-0.030	-0.105*	-0.034	-0.074
5. Authority	0.144*	0.141*	0.213**	-0.039	--	0.298**	0.444**	0.083	0.126*	0.162**
6. Truth	0.175**	0.138*	0.002	-0.079	0.298**	--	0.128*	0.105*	0.101*	0.035
7. Certainty	-0.035	-0.047	0.291**	-0.030	0.444**	0.128*	--	-0.012	-0.013	-0.026
8. Numeracy	0.229**	0.156*	-0.056	-0.105*	0.083	0.105*	-0.012	--	0.108*	0.079
9. ENG1101 Grade	0.398**	0.329**	-0.037	-0.034	0.126*	0.101*	-0.013	0.108*	--	0.759**
10. Overall GPA	0.397**	0.339**	-0.003	-0.074	0.162**	0.035	-0.026	0.079	0.759**	--

*$p < 0.05$, ** $p < 0.001$

be obtained (Truth Beliefs). Both Self-Efficacy scales were correlated with the DEBQ Authority and Truth scales and Numeracy. Mindset was positively correlated with the DEBQ Authority and Certainty Scales. It is interesting to note that while not significantly correlated, self-efficacy was negatively correlated with the entity online mindset scale, indicating that in this study higher self-efficacy is correlated to a growth mindset.
With regard to the regression predictions, it was originally expected that the DEBQ Authority and Truth scales and Numeracy would contribute to the regression model of ENG1101 Grade as these are significantly correlated. In addition, the Authority scale was expected to contribute to the model of Overall GPA. However, all of these scales were significantly correlated with the two engineering self-efficacy scales (ESE-I and ESE-II). In performing this regression modeling, I only considered those scales that contributed more than engineering self-efficacy toward the prediction of ENG1101 Grade and Overall GPA ($p > 0.05$), which included gender, mathematics cohort, and the DEBQ Authority scale as described below.

Tables 4.9 and 4.10 show the final regression models for first-semester GPA and ENG1101 course performance, respectively. Looking at the predictions for first-semester GPA, neither numeracy, intelligence beliefs, or the epistemological certainty, justification, and trust subscales significantly increased the predictive power of the model over engineering self-efficacy ($p>0.05$). Engineering Self-Efficacy-I predicted 16% of the variation in first-semester GPA with Engineering Self-Efficacy II adding an additional 1.4% (Table 4.9). Gender contributed an additional 1% toward the prediction of GPA. However, this term contributed differently by gender with female adding a positive term to the regression equation and male adding a negative term.

Specific mathematics cohorts (MA1161 and MA3160) affected the model, with MA1161 introducing a negative term to the regression equation and MA3160 positively affecting academic performance. The addition of mathematics cohort to the prediction of first-semester GPA led to a statistically significant increase in R^2 of 2.5 or 3.1% depending on mathematics group. Enrollment in the MA1160 and MA2160 mathematics cohorts did not affect the model. These are grouped together in Table 4.9. In addition, the DEBQ Authority sub-scale contributed an additional 1% toward the prediction of first-semester GPA. The final regression model for first-semester GPA included both LAESE engineering self-efficacy subscales, gender, epistemological authority beliefs, and mathematics cohort. The addition of gender, mathematics cohort, and DEBQ authority scale added an additional 3.4 – 4.9% of variation in first-semester GPA over self-efficacy.

Table 4.9 Hierarchical Multiple Regression Analysis Predicting First Semester College GPA

	MA1160 / 2160		MA1161		MA3160	
Predictor	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1 Engineering SE-I	0.160	0.303	0.160	0.300	0.160	0.290
Step 2 Engineering SE-II	0.014	0.146	0.014	0.120	0.014	0.117
Step 3 Gender (Female / Male)	0.010	0.108 -0.108	0.010	0.102 -0.102	0.010	0.108 -0.108
Step 4 DEBQ Authority	0.010	0.101	0.010	0.105	0.010	0.120
Step 5 Mathematics cohort	NA	NA	0.031	-0.179	0.025	0.164
Total R^2	0.194		0.215		0.209	

In the second regression model (prediction of ENG1101 course grade), none of the DEBQ sub-scales, mindset, or numeracy significantly increased the prediction of ENG1101 course grade over self-efficacy. Therefore, the final regression model only included the LAESE Engineering Self-Efficacy I and II scales and mathematics cohort (Table 4.10). The addition of mathematics cohort to the model led to a statistically significant increase in R^2 of between 1.6 – 2.4% depending on mathematics cohort over self-efficacy alone. Enrollment in a MA2160 and MA3160 cohort both contributed positively to the model whereas enrollment in a MA1161 cohort contributed negatively. Only enrollment in a MA1160 cohort did not add to the predictive ability of the model. The final regression model adds between 0.5% to 2.9% to the prediction of ENG1101 course grade over self-efficacy alone.

Table 4.10 Hierarchical Multiple Regression Analysis Predicting ENG1101 Course Grade

Predictor	MA1160		MA1161		MA2160		MA3160	
	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1 Engineering SE-I	0.157	0.315	0.157	0.313	0.157	0.318	0.157	0.306
Step 2 Engineering SE-II	0.009	0.123	0.009	0.100	0.009	0.111	0.009	0.101
Step 3 Mathematics Cohort	NA	NA	0.024	-0.156	0.018	0.136	0.016	0.131
Total R^2	0.165		0.189		0.184		0.182	

4.3 Research Question 3

Research Question 3 focused on determining how students perceive the usefulness of the reflective KWL activity to their learning process. To determine this, I obtained the student submissions for the KWL Reflection Surveys from the four ENG1101 experimental group instructors. As mentioned previously, there were 353 students who responded to this survey for a response rate of 83.3%. The first three questions from the survey quantified the number of KWL activities completed by the students, how much effort they put into the activities, and on which step (K, W, or L) they focused their time. Analysis of the first three questions revealed that 51% (180 students) completed all nine KWL exercises throughout the semester with an additional 118 students (33%) only missing one or two (Figure 4.3). However, the majority of students (n = 174, 55%) put less than 60% of their effort into completing this survey as shown in Figure 4.4. This effort was distributed unequally across the various stages of the KWL with 16% of the students spending the most effort on the "What I **K**now" step, 35% on the "What I **W**ant to Know" step, and 49% of students focusing their effort on the "What I **L**earned" step.

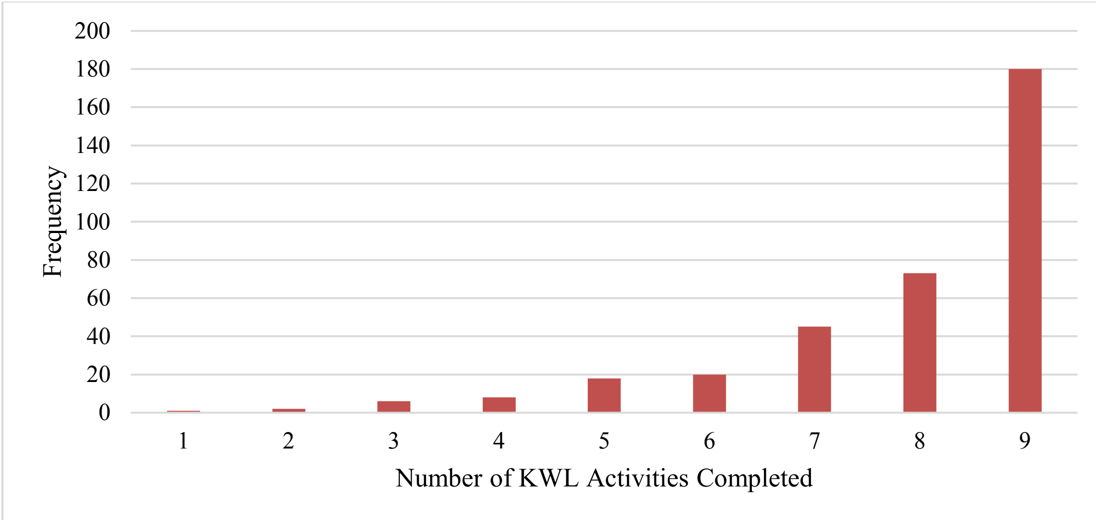


Figure 4.3. Student KWL Reflection Survey Responses: "How many KWL assignments did you complete?"

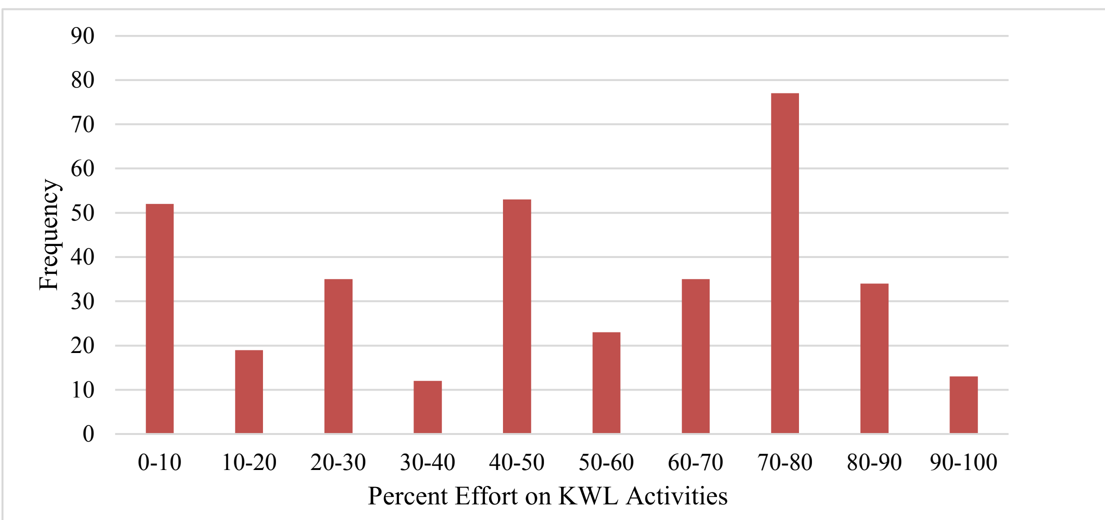


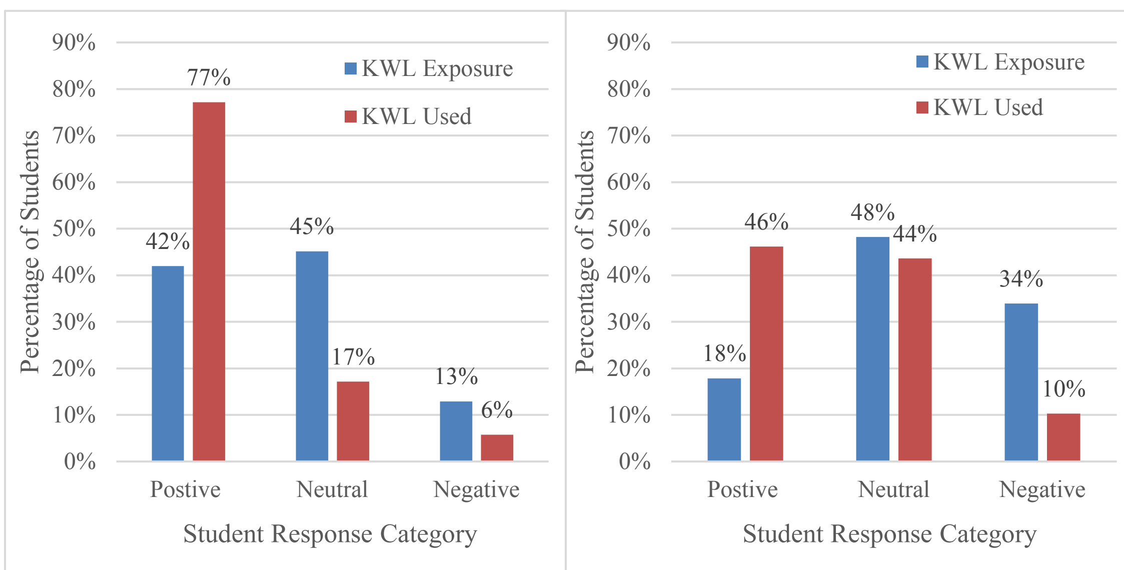
Figure 4.4 Student KWL Reflection Survey Responses: "On a scale of 0 to 100%, how much effort and thought did you put into completing the KWL assignments?"

The remaining questions on the KWL Reflection Survey provided qualitative data on student reported impacts of the KWL activities on their learning and attitudes towards learning. I took a 5-cohort convenience sample from the students I instructed to use in this qualitative data analysis. After analyzing these five cohorts as described in Chapter 3, I checked my results against other sections to determine if I reached saturation (i.e., no additional or different results obtained) (Merriam & Tisdell, 2015; Saldaña, 2015). As no new results or themes emerged, the results below are from the 5-cohort convenience sample only.

As described in Chapter 3, I began my analysis by reviewing the student reported impacts of KWL on their perceived learning and attitudes towards learning and characterized them as positive, negative, or neutral. This information was used to determine the frequency of student responses. As shown in Figure 4.5a, students in the KWL Used group (n = 40) reported more positive impacts on learning than the KWL Exposure group (n = 62). Approximately the same number of students in both groups found positive impacts on their learning (KWL Used = 27, KWL Exposure = 26). The remaining students indicated that the KWL exercises did not help or did not impact their learning (neutral).

Student comments regarding the KWL activity itself were not all positive. Approximately 34% (n=34) of students indicated that the activities did nothing for their learning, with the KWL Exposure group having a higher proportion of students in this category (82%). However, eight of these 34 students (23.5%) conversely explained how the activities helped them prepare for class. One characteristic response to the question "In what ways, if any, do you feel that the KWL exercises impacted your learning this semester?" one student (of the eight mixed responses) had the following response: *"Not much at all. Seemed like extra fluff that could easily have been put in prelesson description, though it did make it a bit easier to figure out what information to focus on* *during the week."* This would seem to indicate that the use of KWL positively impacted the learning for the majority of students.

The student-reported attitudes towards learning were less positive than the impacts on learning (Figure 4.5b). Again, student reported attitudes toward learning were more positive in the KWL Used group with 46% (n = 18) reporting positive values as compared to only 18% (n = 10) of the KWL Exposure group. The remaining students indicated that the KWL exercises did not help or did not impact their attitudes towards learning, with 34% (n = 21) of the KWL Exposure Group and 10% (n = 4) of the KWL Used group reporting negative attitudes as a result of the KWL assignments.



(a) (b)

Figure 4.5 Student self-reported responses to KWL Reflection on (a) impact on learning and (b) attitudes toward learning with KWL

To further investigate how the KWL activities impacted student learning, I used open, inductive coding to manually code the qualitative data for those question responses. Once these codes were created, I used focused coding to develop the themes summarized in Table 4.11 below. Two themes emerged from reading the responses; students in both the KWL Used and KWL Exposure groups who reported positive learning from the KWL activities tended to use the KWL activity to 1) help them focus their learning for the week (Focused Learning) or 2) reflect on their learning (Reflective Learning).

Table 4.11 Inductively Developed Thematic Categories from KWL Reflection

Category	Thematic category	Key terms	Characteristic Level 3 Response
Q6. In what ways, if any, do you feel that the KWL exercises impacted your learning this semester?			
L1	Focused Learning	Prioritize, expectations, goals, outline, focus, overview, plan, organize	"I think they kept me on track, and made me recognize what my learning tasks were so that I could focus on what I was suppose to be understanding for that week."
L2	Reflective Learning	Summarize, reflect, review, think	"It was a way in which you could reflect on what you learned after the week and gave you insight on what you need to learn still and what you have learned so far."

Forty students (39.2%) described the impact of learning as one that was used to prepare for the week. Several characteristic responses include such statements as *"I was able to prepare and do the prelessons more effectively*", and *"Doing the beginning of the KWL aided my learning because it gave me a preview of what topics would be covered in* *the upcoming week."* In addition, thirteen students (12.7%) commented that the KWL activity allowed them to focus on their learning more meaningfully

- *"The KWL exercises helped me set goals to focus on what to learn each week"*
- *"KWL activities helped me to stop and think before even starting about what exactly I was supposed to be learning and how I should be progressing in the class. They helped to articulate what my objectives were and what my performance was on those objectives."*
- *"It made me more of what I was meant to get out of each week and made me more focused on certain parts of the class itself."*

Eleven students (10.8%) focused primarily on the last stage of the KWL activity and used it to track or review their progress in the class as shown in the quote in Table 4.11. One example that demonstrates this theme is:

> *They helped summarize what I learned every week, and what I should expect to learn. It was nice to have an idea for what was going to happen and the topics that we were going to learn about, and I feel like I was more on top of assignments because I knew what was going to happen.*

While this theme was not expressed as frequently as Focused Learning, these eleven students were able to positively impact their learning by using the KWL for Reflective Learning.

4.4 Evaluation of ex post facto Grouping

One of the major limitations of this study is the reliance on student reported effort as the independent variable used in the ex post facto analysis. To address this limitation, my thesis committee recommended using an alternative method to evaluate student use of the KWL assignments. I chose to grade four of the ten KWL assignments for the students in the experimental group. These four KWL assignments were randomly selected to span the semester (beginning, middle, and end) to determine if the students were a) submitting the assignments at all, b) submitting the bare minimum to get a complete grade on the assignment (e.g., the K, W, and L columns had content), or c) submitting a complete KWL worksheet that demonstrated satisfactory effort.

I used a pass/fail grading system on this analysis, where a grade of 0 (fail) was given to students who met one of the following characteristics: did not submit the assignment, only copied and pasted the given objectives to the KWL columns, or did not use the given objectives in the worksheet. A grade of 1 (pass) was given to students who met the following characteristics: used the given objectives to describe what they already knew, set meaningful learning goals, and described what they learned and still need to learn in their own words. Students who passed three or four of the sampled KWL assignments were classified as having used the KWL assignments. Those who passed zero, one, or two, were classified as having not used the KWL assignments. The sampling distribution of this ex post facto grouping is shown in Table 4.12 below.

The distribution of the students in the experimental groups (KWL Exposure and KWL Used) shifted using the new ex post facto methodology (e.g., instructor pass/fail grading). This shift included students who were originally classified as KWL Exposure who I determined put forth a passing effort on 3 or more of the sampled KWL assignments and were reclassified as KWL Exposure (n = 35). This shift also included students who originally were classified by student effort as KWL Used that I determined did not put forth passing effort on 3 or more of the sampled assignments (n = 69). These students were reclassified as KWL Exposure.

Table 4.12 Sample distribution of revised pre-post survey results

Control Group (n = 163)		KWL Exposure (n = 164)		KWL Used (n = 83)	
Math Cohort	Gender	Math Cohort	Gender	Math Cohort	Gender
MA1160 (n = 44)		MA1160 (n = 41)		MA1160 (n = 22)	
MA1161 (n = 39)	Male (n = 120)	MA1161 (n = 43)	Male (n = 118)	MA1161 (n = 25)	Male (n = 51)
MA2160 (n = 40)	Female (n = 43)	MA2160 (n = 37)	Female (n = 46)	MA2160 (n = 20)	Female (n = 32)
MA3160 (n=30)		MA3160 (n=33)		MA3160 (n=10)	

Only 37% of the students that were classified in the original KWL Used group using student reported effort remained in this group when using instructor pass/fail grading. Seventy-five percent of the students in the KWL Exposure group were classified in this same group using the instructor pass/fail grading. Overall the correlation between students in the original and the new KWL ex post facto grouping is low (r = 0.131) with only 58.6% (n = 147) classified in the same categories by both methods. This low correlation strongly suggests that student reported effort is not measuring the same outcome as grading the assignments. The question on the reflection survey asked the students how much effort and thought they put into completing the KWL assignment, which is different from meeting the assignment requirements from an instructor perspective.

It is important to make note of some observations about the nature of the KWL assignment submissions as I graded them. As can be inferred from the large shift in students from the KWL Used to the KWL Exposure group, while many students reported that they had put effort into their assignments, grading these assignments revealed that this effort did not necessarily translate into meeting the assignment requirements. Without instructor feedback to the contrary, students may have misinterpreted what they were supposed to do for the KWL assignments. Many students simply copied and pasted the week's learning objectives into the various KWL columns and, while this may have consisted of some effort to determine which objective went where, they did not demonstrate that they used the KWL assignment for either preparation or reflection of the week's work. From an instructor perspective, it appeared that students did the bare minimum to complete the assignment.

One other interesting observation was that, of the four experimental sections, 46% (n = 38) of the students classified in the alternative KWL Used group were in the section that I instructed. Throughout the semester, the majority of the instructors used their LEAP Leaders (the student mentors present in the classroom) to grade the KWL Assignments, but I graded the KWLs myself. As students can see who graded these assignments, it is possible to infer that the presence of the instructor in the grading process may have impacted the quality of the work being submitted, even though the assignments were graded on completion. However, without being graded for content, the quality of the submissions of the majority of the students was still below the pass level.

After completing the new ex post facto grouping, I reran the analyses to account for this change. As with the first grouping, there were significant differences ($p < 0.05$) in the LAESE SE-I and the DEBQ Justification Beliefs subscales between the test groups, which were controlled for in the analysis of the post test data. These changes in ex post facto groupings do not impact the results presented in the prior sections of this chapter. As, there were no significant differences between these test groups on any of the measured scales, these results are not presented here.

5 Conclusions

This work has sought to answer three main research questions:

1. How does the implementation of the KWL exercise impact self-efficacy, intelligence beliefs, and epistemological beliefs in first-year engineering students? What, if any, differences exist between gender?
2. What, if any, are the effects of self-efficacy, intelligence beliefs, and epistemological beliefs on academic performance? What, if any, differences exist between gender?
3. How do first-year students perceive the usefulness of the reflective KWL activity to their learning process?

In this chapter, I outline the overall limitations of the study methods and findings. This is followed by a discussion of the implications of the results from Chapter 4 and suggestions for future avenues of research that can build upon this work.

5.1 Limitations

Before discussing conclusions and implications from the results, two main limitations of this study need to be addressed. First, the survey methods differed for the initial pre-survey between sections, which greatly affected the response rate for the pre-survey. For the majority of the sections (both experimental groups and the control group), the survey was provided to the students as a 10 point assignment. However, for 50% of the students in the control group, the survey was sent to them via email and was not part of a class assignment. This may have affected the results from the control group as only those students who were motivated or interested in the research were more likely to respond and may not be a representative sample of this population.

Secondly, the initial ex post facto classification of experimental grouped students into KWL Exposure and KWL Used was solely based on the students' self-reported effort in the KWL activities. This means that a student could over or under estimate their effort on the assignments and be misclassified, as demonstrated in the modified ex post facto classification in Section 4.4. A way to improve this would be to evaluate each student's responses to the KWL activities based on quality rather completion, and classify them based on that analysis. This process would take a significant time commitment for an instructor, but would eliminate the possibility of mis-classification and increase student buy-in as they would be graded on their effort.

5.2 Research Question 1

To address research question 1, I examined the pre- and post-test results on the self-efficacy, intelligence beliefs, and epistemological belief scales between gender, mathematics cohorts, and test groups. The next few sections discuss the conclusions and implications of these results from Chapter 4.

5.2.1 Self-Efficacy

Two LAESE engineering self-efficacy scales were used to measure the student's perceptions of their ability to succeed in engineering courses (ESE-I) and their confidence in their abilities (ESE-II). With regard to gender, the pre-test results on the LAESE Engineering Self-Efficacy I scale (ESE-I) indicated that female students had significantly lower engineering self-efficacy than their male counterparts upon entering the university. In other words, female students were less confident in their ability to succeed in their engineering course, which is consistent with the literature (Betz & Hackett, 1981; Hill et al., 2010; Hutchison et al., 2006; Lent et al., 2008; Marra et al., 2009; Pajares & Miller, 1994; Summers & Hrabowski III, 2006).

Evaluating the initial differences between mathematics cohorts revealed that students enrolled in the MA1160 and MA1161 cohorts showed significantly lower levels of incoming ESE-I than students enrolled in MA3160. These differences in self-efficacy may be due to experience, as students in the lower-level mathematics cohorts have not had as many mastery experiences in mathematics compared to students enrolled in MA3160. These differences are important to note as previous research has demonstrated the effects of mathematics cohort on ENG1101 course performance (Kemppainen et al., 2015) and the effects of self-efficacy on course performance (e.g., Lent et al., 1986; Marra et al., 2009). If these effects are additive, students in MA1161 may be at a significant disadvantage when compared to other first-year engineering students.

Looking at the test groups (Control, KWL Exposure, KWL Used) showed that students in the KWL Exposure group initially showed significantly higher ESE-I scores than the Control group and higher ESE-I scores than the KWL Used group. This implies that self-efficacy might play a role in a how student chooses to participate in learning activities such as KWL, with students with higher initial confidence in their ability to succeed less likely to use reflective learning exercises. This relationship is discussed in more detail below.

Despite these initial differences between the ESE – I scale scores (ability to succeed in courses) between male and female students, test groups, and mathematics cohorts, there were no significant differences in the ESE – I scale values at the end of the semester. In general, it appears that the majority of first-year engineering students experience a *drop* in their self-efficacy in their first-semester of college with the exception of students enrolled in MA3160. This may be due to the nature of the questions on the LAESE ESE-I scale. The questions specifically define success as "earning an (A or B) in (math, chemistry, and physics)". Towards the end of the semester, students have a quantitative value of their grades in these courses, which may be lower than they expected coming into the semester. Because students in MA3160 have historically performed significantly higher than the other mathematics cohorts (Kemppainen et al., 2015), it stands to reason that their expectations of their abilities (i.e., self-efficacy) align well with these higher grades.

Student responses on the ESE-II scale indicated no initial differences in confidence in abilities between genders. This implies that despite having a lower confidence in their ability to succeed in their engineering course, female students had the same confidence in their engineering abilities overall as their male counterparts. In addition, incoming students in MA1161 were less confident in their abilities (ESE-II), scoring lower on this measure than their MA3160 counterparts. This may be due to the lower amount of mastery experiences with regard to mathematics as discussed previously. With regard to test group, students in the KWL Exposure group showed significantly higher scores on the ESE-II than the Control group and higher scores than the KWL Used group. These results reinforce the idea that self-efficacy may impact how students choose to participate in reflective exercises, which is discussed below.

At the end of the semester, there were no significant differences between gender or mathematics cohort in post-test ESE-II values. However, significant differences were found between test group, with students in the Control group finishing the semester with higher scores than those students in the KWL Exposure group. This is a switch from the start of the semester where the KWL Exposure group reported the highest initial ESE-II scores. The KWL Exposure group also reported lower post-ESE-II scores than the KWL Used group at the end of the semester. As there are no significant differences between the Control group and the KWL Used group, there does not appear to be evidence to support the hypothesis that KWL activities impacted the overall self-efficacy of students. However, with the KWL Used group more efficacious than the KWL Exposure group at the end of the semester, this relationship continues to suggest a relationship between self-efficacy and the use of KWL activities.

No other significant one or two-way interactions were discovered on ESE-II scores at the end of the semester. While not significant in the post-test, female students still reported lower scores on average at the end of the semester on both ESE-I and ESE-II values compared to male students. Because the post-test results were not significantly different between female and male students, it is possible that the gender gap in self-efficacy may shrink by the time they finish their first semester of engineering coursework. With regard to mathematics cohorts, the trends shown at the beginning of the semester continued to the end, with MA1161 cohorts reporting the lowest ESE-II scores and MA3160 cohorts reporting the highest. Student responses to the ESE-II questions (confidence in abilities) may be impacted by their experiences in their first-semester coursework. Students may be comparing their skill set to their peers or even to their grades to determine their level of ability. If a MA1161 student is comparing themselves to a peer in a higher mathematics cohort, they may judge their abilities as lower and report a lower ESE-II score.

5.2.2 Intelligence Beliefs

Initially, the incoming first-year engineering student intelligence beliefs were distributed with 47.8% growth mindset, 39.8% mixed, and 13.7% as fixed mindset. These distributions did not vary initially by gender or test group, but did vary by mathematics cohort with MA1161 showing higher proportions of growth mindset compared to MA1160. These results are consistent with the literature that suggests that undergraduate engineering students have more of a growth mindset (Stump et al., 2014). This seems to indicate that engineering students have a slightly different mindset profile than other student population groups (e.g., 40% growth, 20% mixed, 40% fixed, Dweck, 2008).

At the end of the semester, female students showed a greater tendency toward growth mindset than their male counterparts. The distribution at the end of the semester was still shifted overall toward a growth mindset. These results reflect others' work such that female engineering students shifted more toward growth mindset than male students over the course of a semester (Rogers et al., 2016). However, the results presented in this study are contrary to other research that suggests male students are more likely to possess a growth mindset over female students, who are more likely to have a fixed mindset

(Chen & Pajares, 2010; King & Magun-Jackson, 200). These differences in results for engineering students with regard to gender and mindset warrant further investigation.

5.2.3 Epistemological Beliefs

There were differences with regard to gender in the incoming certainty epistemological beliefs with male students having higher incoming certainty beliefs (less sophisticated beliefs) compared to female students. These findings are consistent with others' research (e.g., Jehng et al., 1993; Paulsen & Wells, 1998; Trautwein & Lüdtke, 2007) which indicates that students enrolled in engineering may be more likely to possess naïve certainty beliefs; however, these studies did not consider gender, which may be important as engineering student populations tend to be male dominated (Elenich & Russell, 2017). Controlling for these initial differences indicated a significant interaction between test groups with students in the KWL Used group demonstrating less sophisticated certainty beliefs at the end of the semester than the KWL Exposure group. This would indicate that students who completed the KWL activities were more likely to search for only one correct answer (Schommer, 1990), which may foreshadow lower course grades long term (Paulsen & Wells, 1998; Schommer, 1990; Trautwein and Lüdtke, 2007).

While there were more sophisticated justification beliefs in the KWL Exposure group compared to the Control group, no significant differences were found in the post-test results. While not significant, it is interesting to note that the Control group and KWL Exposure group had less sophisticated Authority and Justification beliefs than the KWL Used group. In addition, the Control group had less sophisticated Truth beliefs than the KWL Exposure and KWL Used groups. This may imply that the use of KWL leads to an increase in the sophistication of these beliefs in first-year engineering students, but further work is necessary.

Additionally, while there were no significant differences found between gender, test groups, mathematics cohort or time(pre/post) on the Justification, Authority and Truth scales of the DEBQ survey, it is worth noting some general trends within the data. Across all of these subscales, the data were normally distributed, indicating that first-year engineering students do not display extreme views toward these beliefs. Very few students adhere to the strict (low) epistemological beliefs that teachers know all of the answers or can find one absolute answer and first-hand experience is the only way to justify knowledge. Additionally, the majority of students did believe in the other extreme (sophisticated) epistemological beliefs where knowledge is contextual, can be justified by research, and uncertain. These results are contrary to literature that suggests than engineering students do not have sophisticated epistemological beliefs, particularly within the first-year (Pavelich & Moore, 1996; Trautwein & Lüdtke, 2007; Wise et al., 2004).

To summarize, the changes in the self-efficacy, intelligence beliefs, and epistemological beliefs appear to be minimally impacted by the implementation of the KWL exercise. No significant results were found between test groups on LAESE Self-Efficacy I scale (ability to succeed in courses), mindset, and DEBQ Authority, Justification, and Truth scales. However, there were significant differences found in the LAESE Self-Efficacy II scale (confidence in abilities) and DEBQ certainty beliefs. With respect to certainty beliefs, the KWL Used group demonstrated lower sophisticated certainty beliefs at the end of the semester than the KWL Exposure group. This indicates that the students in the KWL Used group were more likely to believe that knowledge is certain than students in the KWL Exposure group. With the tendency to look for only one answer, these students may have more difficulty demonstrating creativity in their problem solving. These are primarily long-term concerns that were not included in this study, but the potential implications of lower epistemological beliefs warrant a longitudinal study of engineering students.

With respect to the KWL impacts on self-efficacy, students in the KWL Exposure group started with the highest self-efficacy and saw the most significant decrease in their self-efficacy between the beginning and end of the semester. Students in the Control and KWL Used groups showed a decrease in self-efficacy as well, but not to the same extent as the KWL Exposure group. This appears to imply that the first-semester college experience may impact self-efficacy negatively. This also may indicate an effect of self-efficacy on use of KWL, as students with the highest self-efficacy initially were more likely not to use the activity. This is a relationship that should be explored further.

No significant two-way interactions between test group and gender were found, which indicates that this KWL intervention did not impact gender. However, differences were found between genders on post-test mindset scores with female students showed a greater tendency toward growth mindset than their male counterparts. As these differences are also contrary to prior research regarding gender and mindset, this relationship should be investigated further especially with respect to engineering populations. With female middle and high school students reporting fixed beliefs toward science and mathematics (Chen & Pajares, 2010; Correll, 2001) and studies on engineering populations reporting mixed results (Rogers et al, 2016; Stump et al., 2014), this implies that intelligence beliefs for engineering may be different than science and mathematics beliefs. As engineering student populations are typically male-dominated, it is necessary to analyze results on engineering students by gender to determine the role of intelligence beliefs in engineering student success.

5.3 Research Question 2

Using a hierarchical multiple regression, I analyzed how intelligence beliefs, the DEBQ epistemological beliefs subscales, mathematics cohorts, gender, and Numeracy predict student success in the course compared to self-efficacy alone. The final regression model for ENG1101 course performance only included three factors: LAESE Engineering Self-efficacy I and II and mathematics cohort. This model explained between 16.5% - 18.9% of the variation on course performance. These findings indicated that between 0.5% - 2.9% of this variation on course performance is due to mathematics cohort, with the remaining 16.5% due to self-efficacy. When predicting first-semester college GPA, two additional factors made impacts on the regression model: gender and the DEBQ Authority subscale. Being female adds a positive term to the regression equation, while male adds a negative term. This implies that female students are predicted to have a higher first-semester GPA than their male counterparts. The inclusion of the DEBQ Authority scale, which measures a student's belief in the source of knowledge, indicates that more sophisticated authority beliefs indicates higher academic performance. Both of these terms each add an additional 1% to the prediction of first-semester GPA and mathematics cohort adding between 2.5 – 3.1% to the regression model. This model explains between 19.4% - 21.5% of the variation on first-semester GPA.

Looking at the final regression models, self-efficacy was the most significant predictor of both student academic success measures (ENG1101 course performance and first-semester GPA). As expected, these results are consistent with the self-efficacy literature, which suggests a strong relationship between self-efficacy and academic performance (Bandura, 1986; Correll, 2001; Parsons et al., 1984). It is important to note that the effects of mathematics cohort vary, with the MA1161 cohort adding a negative term to the regression model and MA3160 adding a positive term. This indicates that students enrolled in the MA1161 cohort are predicted to have a lower ENG1101 grade and lower first-semester GPA than the other mathematics cohorts. In addition, students enrolled in the MA3160 mathematics cohorts would have a higher ENG1101 grade and higher first-semester GPA than the other mathematics cohorts. It is interesting to note that the effects of mathematics cohort, while small, do reflect a measureable performance outcome that has been found in prior research (Kemppainen et al., 2015). This would seem to indicate that these results are practically significant as well as statistically significant and should be considered and controlled for in future studies on this population. It may also indicate that a stronger mathematics background is essential for success in engineering.

Although I expected to see the DEBQ Truth scale as well as Numeracy in this regression model, they were not found to be significant contributors above self-efficacy. This is most likely due to the significant correlations these terms have with self-efficacy, as noted in Chapter 4. Therefore, while it may be possible that these terms can play a role in the prediction of academic success, they are overshadowed by the contribution of self-efficacy toward performance. It is important to note that, while several studies have demonstrated a relationship between growth mindset and higher performance (Aditomo, 2015; Blackwell et al., 2007), in this study intelligence beliefs were not found to be a significant predictor of either ENG1101 grade or overall first semester GPA. These results confirm those by Stump et al. (2014), whose study of engineering students found no significant relationships between intelligence beliefs and course performance. Again, this warrants additional studies using an engineering student population.

To summarize, only the DEBQ Authority subscale and gender added significantly to the prediction of academic success of first-year engineering students over the expected contributions of self-efficacy and mathematics cohort. The expected DEBQ Truth scale and Numeracy were not found to be significant predictors of academic success, likely due to their significant correlation with self-efficacy. Additionally, mindset did not significantly contribute to the regression models, despite existing literature that suggests otherwise.

5.4 Research Question 3

I obtained student responses from the KWL Reflection Survey to determine how first-year students perceived the usefulness of the reflective KWL activity to their learning process. Approximately 84% of the students in the experimental group completed most of the KWL activities, but most stated they did not put a lot of effort into completing the survey. Attitudes towards the KWL were mixed with students in the KWL Used group reporting more positive impacts on learning and attitudes towards learning than the KWL Exposure group. Recalling that students in the KWL Exposure group were those students who self-reported that they put less than satisfactory (70%) effort into this activity, these results indicate that the students who put less effort into the activity also perceived lower rewards or gains. Twenty-nine percent of the students who indicated negative learning or attitudes towards learning generally found the activity to be a waste of their time. Students who positively reviewed the activity reiterated how they used the activity to impact their learning and saw positive gains.

Analysis of written responses revealed two themes related to how the KWL activities impacted student learning. With the first theme, Focused Learning, students reported using the KWL activities to preview or prepare for class time. The KWL activity allowed them to prioritize their learning, set goals, outline what they should be learning, focus their learning, and to get an overview of what was coming up. Students indicated that they spent the majority of their effort on the last stage of the KWL: what they learned. This is indicative of the second theme on how the activity was used: Reflective Learning. Students used the KWL to summarize, reflect, review, or think about what they learned or should have learned during the week.

Literature suggests that completion rates and attitudes may be a result of a fixed mindset. For example, Stump et al. (2014) stated that intelligence beliefs affected how engineering students use learning strategies, with students having a fixed mindset less likely "to engage in knowledge-building behaviors or collaborative learning strategies" (Stump et al., 2014, p. 1). In addition, studies indicate that students with a fixed mindset have significantly lower levels of intrinsic motivation (Haimovitz et al., 2011), lower goal setting behaviors, (Burnette et al., 2013) and lower goal monitoring behaviors (Bahnik & Vranka, 2017; Burnette et al., 2013). A student lacking these behaviors would be less likely to engage in a reflective learning activity such as KWL. However, as no significant differences were found in mindset between the test groups in this study, the causal nature of participation in the KWL activities should be investigated further.

The low effort in completing the KWL activities could have been indicative of lower epistemological beliefs; however, there were no significant differences between the KWL Exposure or KWL Used groups to indicate this. Schommer (1990) indicated that when a student possesses lower epistemological beliefs, they may be more likely to provide simple answers to problems. To look at Perry's model, rather than advancing to a more sophisticated viewpoint, a student may use the modes of deflection: retreat, escape, or temporizing. As mentioned previously, students may choose these modes when they feel "unprepared, resentful, alienated, or overwhelmed" (Perry, 1999, pg. 65). They obey the dictates of the assignment, in this case, complete the KWL activity, but do not engage in the activity in a meaningful way. Another explanation may be due to the higher initial self-efficacy in the KWL Exposure group. Students with higher initial confidence in their abilities to succeed in academic courses may explain why this group chose not do to the KWL activities seriously. They did not see the need to utilize this additional reflective learning tool. This suggests that if an instructor desired to have this population of students see the benefits of the KWL activity, they would need to engage student participation and buy-in for this activity. As previously discussed, how the assignment is graded should be carefully considered. For this study, the KWL activities were graded on completion only, which allowed students to put little to no effort into the assignment. By grading based on content and providing feedback to the students, this may increase student buy–in.

5.5 Future Work

While some of the results are not entirely surprising (e.g., female students having lower self-efficacy than their male counterparts), several questions remain and several avenues for further research are present. First, the mindset results for first-year engineering students at Michigan Technological University are inconsistent with the general student population as illustrated by previous literature. These results open a new array of research questions: a) is this unique to our student population or engineering populations nationwide, b) will this be maintained or shift throughout their undergraduate curriculum, and c) what is the relationship between gender and mindset in engineering populations nationwide? Similarly, the epistemological beliefs of first-year students are different that prior literature for engineering populations. Is this unique to Michigan Tech? Will this be maintained throughout their undergraduate curriculum? What are the variations observed by gender?

There are a number of questions regarding student participation and attitudes towards the KWL activities that warrant further investigation as well. As mentioned previously, one of the major limitations of the study was the lack of student buy-in and effort that necessitated the ex post facto split of the experimental group. Efforts need to be made to increase the student participation and buy-in for the activities to determine the results of this change on student learning. In addition, while literature demonstrates that less sophisticated epistemological beliefs may contribute to why a student may not choose to complete a reflective leaning activity such as KWL, the differences on these measures were not significant in this study. To that end, repeating the study, grading the activities, and analyzing the KWL activity responses would be a way to determine the underlying motivations regarding student behaviors and attitudes towards use of this reflective learning activity.

6 Reference List

1. Achenbach, G. G., & Cintron, L. G., & Cohoon, J. M., & Sadler, P. M., & Sonnert, G. (2015, June), Career Priorities and the Challenge of Recruiting Women to Computing Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. doi:10.18260/p.23667
2. Adeyemo, D. A. (2007). Moderating influence of emotional intelligence on the link between academic self-efficacy and achievement of university students. *Psychology and developing societies*, *19*(2), 199-213. doi: 10.1177/097133360701900204
3. Aditomo, A. (2015). Students' Response to Academic Setback: 'Growth Mindset' as a Buffer Against Demotivation. *International Journal of Educational Psychology*, *4*(2), 198-222. doi: http://dx.doi.org/10.17583/ijep.2015.1482
4. Aronson, J., Fried, C. B., & Good, C. (2002). Reducing the effects of stereotype threat on African American college students by shaping theories of intelligence. *Journal of Experimental Social Psychology*, *38*(2), 113-125. doi:10.1006/jesp.2001.1491
5. Assessing Women and Men in Engineering (AWE). (2017) Longitudinal Assessment of Engineering Self-Efficacy (LAESE) – Undergraduate Version. https://www.engr.psu.edu/awe/secured/director/diversity/efficacy.aspx Accessed July 7, 2017.
6. Bahník, Š., & Vranka, M. A. (2017). Growth mindset is not associated with scholastic aptitude in a large sample of university applicants. *Personality and Individual Differences*, *117*, 139-143. https://doi.org/10.1016/j.paid.2017.05.046
7. Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, *84*(2), 191. doi: 10.1037/0033-295X.84.2.191
8. Bandura, A. (1986). *Social foundations of thought and action: Asocial cognitive theory.* Englewood Cliffs, NJ: Prentice Hall. ISBN-13: 978-0138156145.
9. Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual review of psychology*, *52*(1), 1-26. https://doi.org/10.1146/annurev.psych.52.1.1
10. Betz, N. E., & Hackett, G. (1981). The relationship of career-related self-efficacy expectations to perceived career options in college women and men. *Journal of counseling psychology*, *28*(5), 399. http://www.apa.org/pubs/journals/cou/
11. Biggs, J. B., & Tang, C. (2011). *Teaching for quality learning at university: What the student does*. 4th edition. McGraw-Hill Education (UK). ISBN 13: 978-0-33-524275-7.
12. Blackwell, L., Trzesniewski, K., & Dweck, C.S. (2007). Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A Longitudinal Study and an Intervention. *Child Development*, 78, 246-263. doi: 10.1111/j.1467-8624.2007.00995.x
13. Boaler, J. (2013, March). Ability and mathematics: The mindset revolution that is reshaping education. In *Forum* (Vol. 55, No. 1, pp. 143-152). Symposium Journals. www.wwwords.co.uk/FORUM.

14. Burnette, J. L., O'boyle, E. H., VanEpps, E. M., Pollack, J. M., & Finkel, E. J. (2013). Mind-sets matter: A meta-analytic review of implicit theories and self-regulation. *Psychological Bulletin*. http://www.apa.org/pubs/journals/bul/
15. Cassidy, S. (2015). Resilience building in students: the role of academic self-efficacy. *Frontiers in psychology*, *6*, 1781. doi: 10.3389/fpsyg.2015.01781
16. Chen, X. (2013). STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001. *National Center for Education Statistics*. https://www.ed.gov/
17. Chen, J. A., & Pajares, F. (2010). Implicit theories of ability of Grade 6 science students: Relation to epistemological beliefs and academic motivation and achievement in science. *Contemporary Educational Psychology*, *35*(1), 75-87. https://doi.org/10.1016/j.cedpsych.2009.10.003
18. Claro, S., Paunesku, D., & Dweck, C. S. (2016). Growth mindset tempers the effects of poverty on academic achievement. *Proceedings of the National Academy of Sciences*, *113*(31), 8664-8668. https://doi.org/10.1073/pnas.1608207113
19. Cokely, E.T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012).Measuring risk literacy: The Berlin Numeracy Test. *Judgment and Decision Making, 7(1),* 25-47. ISSN 1930-2975
20. Correll, S. J. (2001). Gender and the career choice process: The role of biased self-assessments. *American journal of Sociology*, *106*(6), 1691-1730. http://www.jstor.org/stable/10.1086/321299.
21. Dweck, C.S. (1999). *Self-Theories: Their role in motivation, personality and development*. Philadelphia: Taylor and Francis/Psychology Press. ISBN 13: 978-1-84169-024-7.
22. Dweck, C. S. (2002). The development of ability conceptions. *Development of achievement motivation*, *17*, 57-88. http://cachescan.bcub.ro/e-book/580736/pag_57-120.pdf
23. Dweck, C. S. (2007). The perils and promises of praise. *Educational Leadership* *65*(2), 34-39. http://www.ascd.org/publications/educational-leadership.aspx
24. Dweck, C.S. (2008). "Mindsets and math/science achievement," report prepared for *The Carnegie Corporation of New York-Institute for Advanced Study Commission on Mathematics and Science Education,* New York, NY.
25. Dweck, C. S. (2010a). Even geniuses work hard. *Educational Leadership*, *68*(1), 16-20. http://www.ascd.org/publications/educational-leadership/sept10/vol68/num01/toc.aspx
26. Dweck, C. S. (2010b). Mind-sets and Equitable Education. *Principal Leadership*, *10*(5), 26-29. https://www.nassp.org/news-and-resources/publications/principal-leadership/principal-leadership-archives
27. Dweck, C. S. (2016). *Mindset: The new psychology of success*. Ballantine Books. ISBN: 978-0-345-47232-8

28. Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological inquiry*, *6*(4), 267-285. http://hdl.handle.net/10722/44536.
29. Elenich, R., & Russell, A. (2017). *Michigan Technological University 2016 – 2017 Fact Book*, Retrieved from Michigan Technological University, Office of Institutional Analysis. http://www.admin.mtu.edu/ia/Fact_Book/index.html
30. Elby, A., Frederiksen, J., Schwarz, C., & White, B. (2003). Epistemological beliefs assessment for physical science (EBAPS). Recovered from http://www2. physics. umd. edu/~ elby/EBAPS/home.htm.
31. Felder, R. M., & Brent, R. (2004a). The intellectual development of science and engineering students. Part 1: Models and challenges. *Journal of Engineering Education*, *93*(4), 269-277. http://onlinelibrary.wiley.com/doi/10.1002/j.2168-9830.2004.tb00816.x/epdf
32. Felder, R. M., & Brent, R. (2004b). The intellectual development of science and engineering students. Part 2: Teaching to promote growth. *Journal of Engineering Education*, *93*(4), 279-291. http://onlinelibrary.wiley.com/doi/10.1002/j.2168-9830.2004.tb00817.x/epdf
33. Felder, R. M., & Brent, R. (2005). Understanding student differences. *Journal of engineering education*, *94*(1), 57-72. **https://doi.org/10.1002/j.2168-9830.2005.tb00829.x**
34. Fitzgerald, C. J., & Laurian-Fitzgerald, S. (2016). Helping students enhance their grit and growth mindsets. *Journal Plus Education*, *14*(2), 52-67. http://www.uav.ro/jour/index.php/jpe/index
35. Gibbon, G., & Jandrell, I. (2010, June), Changing The Mindset: The Lecturer's Responsibility When Presenting A First Year Course. Paper presented at 2010 Annual Conference & Exposition, Louisville, Kentucky. https://peer.asee.org/16070
36. Good, C., Aronson, J., & Inzlicht, M. (2003). Improving adolescents' standardized test performance: An intervention to reduce the effects of stereotype threat. *Journal of Applied Developmental Psychology*, *24*(6), 645-662. https://doi.org/10.1016/j.appdev.2003.09.002
37. Grant, H., & Dweck, C. S. (2003). Clarifying achievement goals and their impact. *Journal of personality and social psychology*, *85*(3), 541. doi: 10.1037/0022-3514.85.3.541
38. Gratiano, S. M., & Palm, W. J. (2016, June), Can a Five-Minute, Three-Question Survey Foretell First-Year Engineering Student Performance and Retention? Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.26427
39. Haimovitz, K., Wormington, S. V., & Corpus, J. H. (2011). Dangerous mindsets: How beliefs about intelligence predict motivational change. *Learning and Individual Differences*, *21*(6), 747-752. www.elsevier.com/locate/lindif
40. Hill, C., Corbett, C., & St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. American Association of University

Women. 1111 Sixteenth Street NW, Washington, DC 20036. ISBN: 978-1-879922-40-2
41. Hofer, B. K. (1994). Epistemological Beliefs and First-Year College Students: Motivation and Cognition in Different Instructional Contexts. Paper presented at the American Psychological Association, Los Angeles, California. http://www.apa.org/pubs/index.aspx
42. Hofer, B. K. (2000). Dimensionality and disciplinary differences in personal epistemology. *Contemporary educational psychology*, *25*(4), 378-405. doi:10.1006/ceps.1999.1026
43. Hofer, B. K. (2004). Personal Epistemology as a Psychological and Educational Construct: An Introduction. *Personal epistemology: The psychology of beliefs about knowledge and knowing*, Lawrence Erlbaum Associates pg. 1-14.
44. Hogan, M., & Larkin-Wong, K. (2013). Grit and Mindset. *Women Lawyers Journal*, *98*, 11. http://www.nawl.org/p/cm/ld/fid=83
45. Hsieh, P., Sullivan, J. R., & Guerra, N. S. (2007). A closer look at college students: Self-efficacy and goal orientation. *Journal of Advanced Academics*, *18*(3), 454-476. https://doi.org/10.4219/jaa-2007-500
46. Hutchison, M. A., Follman, D. K., Sumpter, M., & Bodner, G. M. (2006). Factors influencing the self-efficacy beliefs of first-year engineering students. *Journal of Engineering Education*, *95*(1), 39-47. http://onlinelibrary.wiley.com/doi/10.1002/j.2168-9830.2006.tb00876.x/full
47. Jacobson, M. J., & Jehng, J. C. (1999). Epistemological beliefs instrument: Scales and items. *Unpublished manuscript*. Taiwan National Central University
48. Jehng, J. C. J., Johnson, S. D., & Anderson, R. C. (1993). Schooling and students′ epistemological beliefs about learning. *Contemporary educational psychology*, *18*(1), 23-35. https://doi.org/10.1006/ceps.1993.1004
49. Jones, A., Lisciandro, J., & Olds, M. A. (2016) Strategies for embedding socio-emotional learning as part of a holistic enabling transition pedagogy. Paper presented at 2016 the 3rd Biennial Conference of The Foundation and Bridging Educators New Zealand (FABENZ), Auckland, NZ. http://fabenzconference2016.com/
50. Kemppainen, A., Fraley, M., Hein, G., & Hamlin, A. J. (2015) Does Student Performance in a Blended Learning Environment Differ Based on Math Preparedness?.2015 7th Annual FYEE Conference Roanoke, VA; August 2-4 2015 http://fyee.asee.org/FYEE2015
51. Kennedy, J., Morton, B., & Fontecchio, A. (2015, October). LEAP: Localized energy awareness program through collaborative K-University STEM projects. In *Frontiers in Education Conference (FIE), 2015 IEEE* (pp. 1-4). IEEE. fie2015.org
52. King, B. A., & Magun-Jackson, S. (2009). Epistemological beliefs of engineering students. *The Journal of Technology Studies*, *35*(2), 56-64. https://doi.org/10.21061/jots.v35i2.a.6
53. Kirk, R. E. (2013) Experimental Design: Procedures for the Behavioral Sciences. 4th Edition, Sage Publications. ISBN: 978-1-4129-7445-5

54. Lent, R., Brown, S. D., & Larkin, K. (1986). Self-efficacy in the prediction of academic performance and perceived career options. *Journal of Counseling Psychology*, 33(3), 265-269. http://www.apa.org/pubs/journals/cou/index.aspx
55. Lent, R. W., Sheu, H. B., Singley, D., Schmidt, J. A., Schmidt, L. C., & Gloster, C. S. (2008). Longitudinal relations of self-efficacy to outcome expectations, interests, and major choice goals in engineering students. *Journal of Vocational Behavior*, *73*(2), 328-335. https://doi.org/10.1016/j.jvb.2008.07.005
56. Lotter, C. (2004). Preservice science teachers' concerns through classroom observations and student teaching: Special focus on inquiry teaching. *Science Educator*, *13*(1), 29-38.
57. Marra, R. M., Palmer, B., & Litzinger, T. A. (2000). The effects of a first-year engineering design course on student intellectual development as measured by the Perry scheme. *Journal of Engineering Education*, *89*(1), 39-45.
58. Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education*, *98*(1), 27-38. http://onlinelibrary.wiley.com/doi/10.1002/j.2168-9830.2009.tb01003.x/pdf
59. Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.
60. Monte, A. E., & Hein, G. L. (2003). Using Engineering Courses to Improve Pre-Calculus Students' Success. *age*, *8*, 1.
61. Nguyen, H. D., & Ryan, A. M. (2008). Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence. *Journal of Applied Psychology, 93*(6), 1314-1334. doi:http://dx.doi.org/10.1037/a0012702
62. Ogando, J. (2008). Teaching the New Engineering Skills-The modern workplace demands cultural and business skills, forcing engineering students to go beyond the fundamentals. *Design News*, *63*(4), 59.
63. Ogle, D. M. (1986). KWL: A teaching model that develops active reading of expository text. *The reading teacher*, *39*(6), 564-570. http://www.jstor.org/stable/20199156
64. Ohland, M. W., Sheppard, S. D., Lichtenstein, G., Eris, O., Chachra, D., & Layton, R. A. (2008). Persistence, engagement, and migration in engineering programs. *Journal of Engineering Education*, *97*(3), 259-278. DOI: 10.1002/j.2168-9830.2008.tb00978.x
65. Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of educational psychology*, *86*(2), 193. http://www.apa.org/pubs/journals/edu/
66. Palmer, B., & Marra, R. M. (2004). College student epistemological perspectives across knowledge domains: A proposed grounded theory. *Higher Education*, *47*(3), 311-335. https://link.springer.com/article/10.1023/B%3AHIGH.0000016445.92289.f1

67. Parsons, J. E., Adler, T., & Meece, J. L. (1984). Sex differences in achievement: A test of alternate theories. *Journal of personality and social psychology*, *46*(1), 26. http://www.apa.org/pubs/journals/psp/
68. Paulsen, M. B., & Wells, C. T. (1998). Domain differences in the epistemological beliefs of college students. *Research in higher education*, *39*(4), 365-384. https://link.springer.com/article/10.1023/A%3A1018785219220
69. Pavelich, M. J., & Moore, W. S. (1996). Measuring the effect of experiential education using the Perry model. *Journal of Engineering Education*, *85*(4), 287-292. http://onlinelibrary.wiley.com/doi/10.1002/jee.1996.85.issue-4/issuetoc
70. Perry Jr, W. G. (1999). *Forms of Intellectual and Ethical Development in the College Years: A Scheme. Jossey-Bass Higher and Adult Education Series*. Jossey-Bass Publishers, 350 Sansome St., San Francisco, CA 94104.
71. Phase, I. I. (2005). *Educating the engineer of 2020: Adapting engineering education to the new century*. National Academies Press.
72. Powers, M. D. (2015). *Growth Mindset Intervention at the Community College Level: A Multiple Methods Examination of the Effects on Faculty and Students* (Doctoral dissertation, University of California, Los Angeles).
73. Rogers, M. J. J., Primeau, R., Hennessey, N. K., & Baygents, J. C. (2016, June). Gender and Self-Efficacy in Engineering: Embracing Failure and a Growth Mindset for Female High School Students (Fundamental). In *123rd ASEE Annual Conference and Exposition*. American Society for Engineering Education.
74. Romero, C., Master, A., Paunesku, D., Dweck, C. S., & Gross, J. J. (2014, February 10) Academic and Emotional Functioning in Middle School: The Role of Implicit Theories. *Emotion*. Advance online publication. http://dx.doi.org/10.1037/a0035490
75. Saldaña, J. (2016). *The coding manual for qualitative researchers*. Sage.
76. Schommer-Aikins, M., Duell, O. K., & Barker, S. (2003). Epistemological beliefs across domains using Biglan's classification of academic disciplines. *Research in Higher Education*, *44*(3), 347-366. https://link.springer.com/journal/11162
77. Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of educational psychology*, *82*(3), 498. http://www.apa.org/pubs/journals/edu/
78. Schommer, M., & Walker, K. (1995). Are epistemological beliefs similar across domains?. *Journal of Educational Psychology*, *87*(3), 424. http://www.apa.org/pubs/journals/edu/
79. Sha, L., Looi, C. K., Chen, W., & Zhang, B. H. (2012). Understanding mobile learning from the perspective of self-regulated learning. *Journal of Computer Assisted Learning*, *28*(4), 366-378. http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1365-2729
80. Shelly, A. C., Bridwell, B., Hyder, L., Ledford, N., & Patterson, P. (1997). Revisiting the KWL: What we Knew; What we Wanted to Know; What we Learned. *Reading Horizons*, *37*(3), 5 pg. 231-242. http://scholarworks.wmich.edu/reading horizons

81. Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of personality and social psychology*, *69*(5), 797-811. http://www.apa.org/pubs/journals/psp/
82. Storek, J., & Furnham, A. (2013). Gender,'g', and fixed versus growth intelligence mindsets as predictors of self-estimated Domain Masculine Intelligence (DMIQ). *Learning and Individual Differences*, *25*, 93-98. https://www.journals.elsevier.com/learning-and-individual-differences
83. Stroll, A. & A.P. Martinich (2016) Epistemology, Encyclopedia Britannica, Encyclopedia Britannica, INC, Published March 2, 2016. Accessed July 11, 2017. URL:https://www.britannica.com/topic/epistemology
84. Stump, G. S., Husman, J., & Corby, M. (2014). Engineering students' intelligence beliefs and learning. *Journal of engineering education*, *103*(3), 369-387. http://onlinelibrary.wiley.com/doi/10.1002/jee.20051/pdf
85. Summers, M. F., & III, Hrabowski, F. A. (2006). Preparing minority scientists and engineers. *Science*, 311. 1870-1871. www,sciencemag.org.
86. Szabo, S. (2007). The KWL strategy: Helping struggling readers build evidence of their learning. *Thinking Classroom*, *8*(2), 32. https://www.rwctic.org/thinking-classroom-journal-2007
87. Trautwein, U., & Lüdtke, O. (2007). Epistemological beliefs, school achievement, and college major: A large-scale longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology*, *32*(3), 348-366. https://doi.org/10.1016/j.cedpsych.2005.11.003
88. U.S. Department of Education, National Center for Education Statistics. (2017) *Undergraduate Retention and Graduation Rates.* Retrieved from https://nces.ed.gov/programs/coe/indicator_ctr.asp
89. Wise, J. C., Lee, S. H., Litzinger, T., Marra, R. M., & Palmer, B. (2004). A report on a four-year longitudinal study of intellectual development of engineering undergraduates. *Journal of Adult Development*, *11*(2), 103-110. https://link.springer.com/journal/10804

A Assessing Engineering Self-Efficacy

Table A.1 LAESE Self-Efficacy Questions (Marra et al., 2009)

Place a check in the column that identifies the extent to which you agree or disagree with the statement. 1 = Strongly Disagree, 7 = Strongly Agree

Survey Items
Engineering Self-Efficacy I 1. I can succeed in an engineering curriculum 2. I can succeed in an engineering curriculum while not having to give up participation in my outside interests (e.g. extracurricular activities, family, sports) 3. I will succeed (earn an A or B) in my physics courses 4. I will succeed (earn an A or B) in my math courses 5. I will succeed (earn an A or B) in my engineering courses
Engineering Self-Efficacy II 1. I can complete any engineering degree at this institution 2. I can do well in an engineering major during the current academic year 3. I can complete the math requirements for most engineering majors 4. I can complete the physics requirements for most engineering majors 5. I can complete the chemistry requirements for most engineering majors 6. I can persist in engineering during the current academic year

B Assessing Intelligence Beliefs

Table B.1 Entity-Only Intelligence Beliefs Survey (Dweck, 1999)

This questionnaire has been designed to investigate ideas about intelligence. There are no right or wrong answers. We are interested in your ideas.

Place a check in the column that identifies the extent to which you agree or disagree with the statement. 1 = Strongly Agree, 6 = Strongly Disagree

Survey Items	1	2	3	4	5	6
1. Your intelligence is something about you that you can't change very much.						
2. You have a certain amount of intelligence, and you can't really do much to change it.						
3. To be honest, you can't really change how intelligent you are.						
4. You can learn new things, but you can't really change your basic intelligence.						

C Assessing Epistemological Beliefs

Table C.1 Discipline-Focused Epistemological Beliefs Questionnaire (DEBQ) for Engineering (Hofer, 2000)

Place a check in the column that identifies the extent to which you agree or disagree with the statement. 1 = Strongly Disagree, 5 = Strongly Agree

Questions
Certainty
1. Answers to questions in this field change as experts gather more information.
2. All experts in this field understand the field in the same way
3. Truth is unchanging in this subject.
4. In this subject, most work has only one right answer.
5. Principles in this field are unchanging
6. All professors in this field would probably come up with the same answers to questions in this field.
7. In this subject, it is good to question the ideas presented.
8. Most of what is true in this subject is already known.
Justification
9. First-hand experience is the best way of knowing something in this field.
10. I am more likely to accept the ideas of someone with firsthand experience than the ideas of researchers in this field.
11. Correct answers in this field are more a matter of opinion than fact.
12. There is really no way to determine whether someone has the right answer in this field.
Source: Authority
13. Sometimes you just have to accept answers from the experts in this field, even if you don't understand them.
14. If you read something in a textbook for this subject, you can be sure it's true.
15. If my personal experience conflicts with ideas in the textbook, the book is probably right.
16. I am most confident that I know something when I know what the experts think.
Attainment of Truth
17. Experts in this field can ultimately get to the truth.
18. If scholars try hard enough, they can find the answers to almost anything.

D Assessing Numeracy

Table D.1 Berlin Numeracy Test Questions (Cokely et al., 2012)

The survey is about Decision Making. You will be presented with statistical and numerical questions. Please DO NOT USE calculators, though you can use paper and pencil to assist you. Please try your best to answer all the questions.

Question	Response Prompt
1. Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in a choir 100 are men. Out of the 500 inhabitants that are not in a choir 300 are men. What is the probability that a randomly drawn man is a member of the choir?	Please indicate the probability in percent.
2. Imagine we are throwing a loaded die (6 sides). The probability that the die shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the die show the number 6?	_____out of 70 throws
3. In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?	Please indicate the probability in percent
4. Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided die show an odd number (1, 3 or 5)?	_____out of 50 throws

E Copyright documentation (see attached)